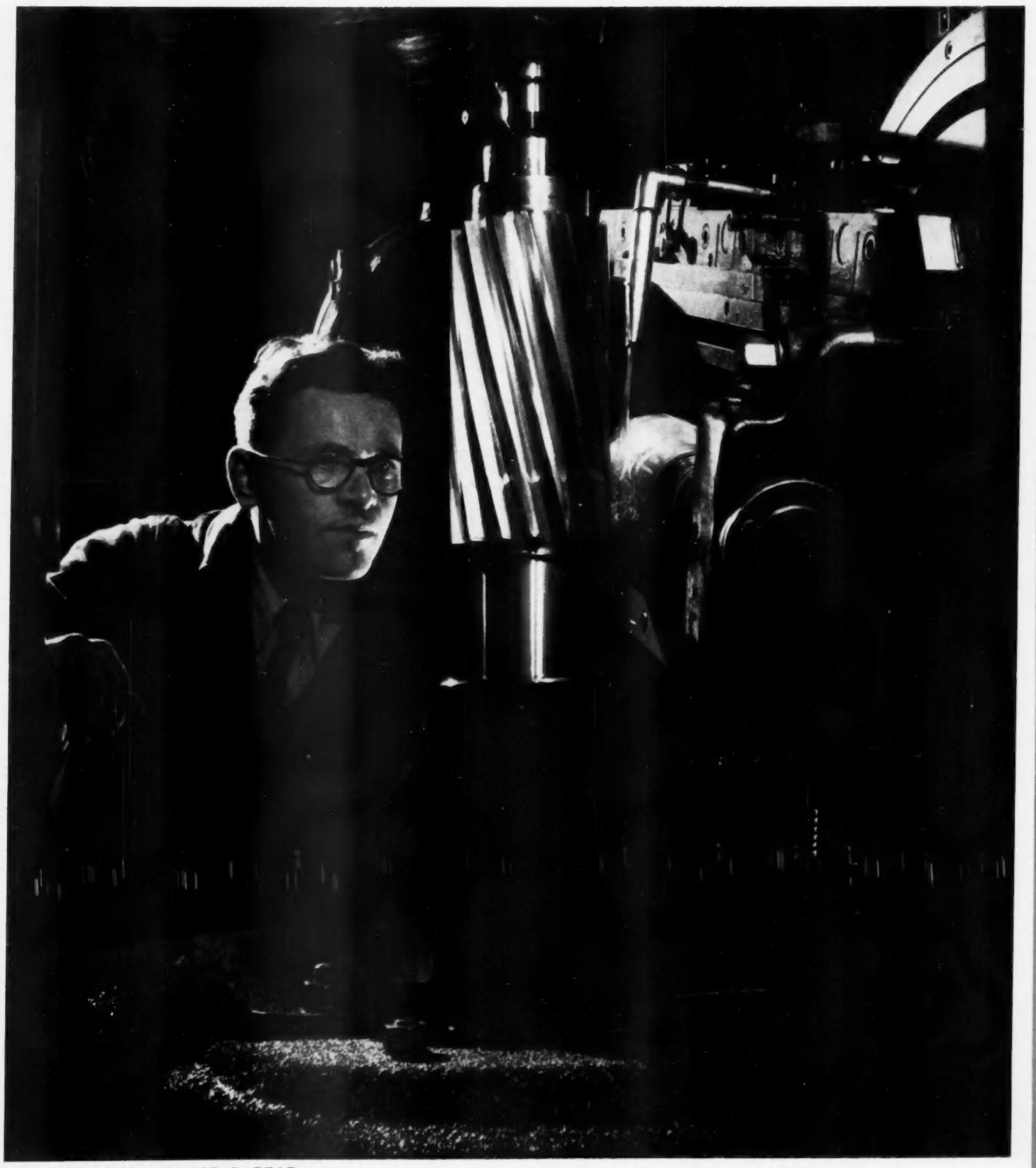
ENGINEERING 25-1-57

ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 - - TELEPHONE: TEMPLE BAR 3663

Vol. 183 No. 4742 *LONDON, FRIDAY, JANUARY 25, 1957* PRICE 2s.



HOBBING A HELICAL GEAR

JANUARY 25, 1957 VOL. 183 PAGES 97–128

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Published every Friday by Engineering Limited, 35 & 36 Bedford Street Strand, London, W.C.2 TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

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Subscription Rates for 12 *months, Inland and Abroad* £5 10*s.*, *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* (2*s.* 3*d.*)

EMBRACING THE FUTURE

A STORY has been told which every engineer should read for it is he, above anyone else, who is personally concerned. It is a story of technical changes and their impact on the managers and men of a steel-works in North Wales. The firm started in the first half of the Nineteenth Century as a clog-making and nail-cutting business in the West Midlands. At the founder's death an enterprising young son took control and started rolling sheet from imported bar, and was the first to use galvanising. In 1896 the company moved to North Wales, where they became, at one time, the largest sheet producers in the country. In the late 1920's the management became aware that a market was arising for thin-gauge sheet of high surface quality, which could not satisfactorily be produced by the hand-mill methods employed, with modifications, since 1896. Americans were brought in to advise, and later to manage an experimental mill. It was not until 1937, however, that the decision was taken to adopt continuous strip rolling and so to re-organise the whole works. The impact of this revolutionary change on the social structure of the works and industrial relations within it was the subject of a three-year study by the Department of Social Science of the University of Liverpoool. The study was undertaken by a team under the leadership of Dr. W. H. Scott.

Dr. Scott and his colleagues are not only concerned with the sociological effects of the change: they describe why and how it came about, and place it in the full context of the company's history and location. The company's name will be known to many of our readers but the authors have been asked not to reveal it, perhaps because of the very full and intimate descriptions of the company, its philosophy, its difficulties and successes. Throughout the period the family have preserved an effective control of the business, and have seen the capital grow from £200,000 (in 1898) to £27 million. Their wish to retain control was, in fact, one of the main social influences which delayed the change to continuous strip rolling. The influence of a management group that was still predominently inbred in the 1930's was another, as was the concern of both groups for the welfare of their employees.

The onset of the acute depression of the early 1930's acted as a further brake on developments and prompted a more thorough exploration of the commercial and social implications of continuous rolling. The decision was, in fact, delayed 10 years. It was taken in 1937, one year after Richard Thomas and Baldwins put down the first continuous strip mill at Ebbw Vale and two years after the chairman of the company had stated in public: "I think great changes will take place in the near future in the methods of manufacturing steel sheets . . . it is quite certain that much of the work which is done by manual labour will, before very long, be done in this country by machinery." Much the same had been said by the managing director to representatives of the Iron and Steel Trades Confederation in 1928, when he told them of what two of the directors had seen in the United States. He asked for the unions' support when the change became necessary, and added ". . . you can depend upon us to protect your interests as well as our own." The excellence and directness of management-union communications, and the clear recognition by both sides of the point of view of the other, were important contributors to the smoothness with which the change was finally effected.

When the founder was in his prime, or thereabouts, Disraeli told the Scots that "Change is inevitable. In a progressive country, change is constant." But it is not constant, evolutionary, change that is the problem. It is the radical change, which disrupts the established social structure of a plant, alters values, uproots tradition and people. It is the kind of change that often creates anxieties, unhappiness and sets up resistances. For technical change usually involves the replacement of human operators by machines and some degree of redundancy in the initial stages, until the expansion made possible by the change creates jobs for those who have been displaced.

The practical implications which the authors attempt to draw from their work will repay close study by everyone with a management problem involving technical change (and equally by those who have just a keen interest in their managerial job). The unions and their members will accept technical change and co-operate in implementing it provided they know precisely where they stand in relation to the change, and provided "specific and effective procedures exist for handling the particular problems that arise." An important role should be assigned to lay representatives of the unions, "who are experiencing the problems themselves and are in close touch with other employees affected." There should be "prior and effective consultation between management and union representatives," and agreed principles governing transfers, re-training, and adequate provision for those not re-absorbed. The suggestion is put forward that the latter should be a joint responsibility of industry and the State.

Some of the results of this inquiry will sound strange and even unlikely to many. For example, workers tend to consider

themselves worse off, even if their pay is considerably higher, if the new work does not match their expectations, or if it means a lower status. The problems of shift-work, the expectation of redundancy, the importance of the social structure within working groups, the high respect paid to seniority, the relatively disappointing attitudes of junior staff, and many other factors, are documented, analysed and discussed. This is a study of outstanding merit.

Technical Change and Industrial Relations, by W. H. Scott, J. A. Banks, A. H. Halsey and T. Lupton. Liverpool University Press (17*s*. 6*d*.)

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Plain Words

The expert always has an advantage over the layman: he can support his prejudices with impressive arguments. But he may nevertheless be wrong. During the war Mr. Duncan Sandys was put in charge of planning defence against German "V" weapons, and came to the conclusion, after reconnaissance photographs had revealed the construction of some strange cylinders near Peenemunde, that the Germans were in fact building long-range rockets. His experts assured him that this was unlikely since the only conceivable fuel for such a purpose was cordite, and cordite was too bulky to give so small a container an effective range. Fortunately, Mr. Sandys was persistent and bomber raids on the Peenemunde site delayed the launching of these rockets—for rockets they were—for six months. Later, it was shown that a mixture of liquid oxygen and alcohol would serve as the necessary fuel.

It might, of course, be suggested that in this case the wrong specialists had been consulted, but even men of the highest vision, if steeped too deeply in their work, can be mistaken as to its potentialities. Lord Rutherford is said to have rejected the possibility of gaining useful energy from nuclear reactions, declaring that the likelihood of a reaction taking place corresponded to the chance of hitting a fly loose in the Albert Hall with the aid of a peashooter; yet Calder Works is already witness to the contrary. It had not occurred to him that in certain circumstances flies could be made to swarm in the Albert Hall, and that a whole audience of promenaders could be equipped with peashooters.

Nowadays we are all laymen outside our own particular fields, and are dependent on the specialist for the information on which to base our judgments. The responsible specialist is necessarily cautious in his advice, but caution can sometimes lead to a closed mind, so that orthodoxy is mistaken for due reserve. This may result in the neglect of valuable ideas.

There seems at present, for example, an unwillingness to regard the possibility of producing power by fusing the hydrogen atoms of seawater as more than of academic interest or at best a long-term prospect. But scientific discovery proceeds in jumps, and fusion power may not in fact be far away. It is after all less than 20 years since Hahn and Strassmann in Berlin first caused fission of uranium atoms by neutron bombardment. Seven years later bombs were detonated based on their discovery; and to-day we have large industries engaged in the construction of uranium-fuelled power stations. Progress on fusion should be even more rapid since we are now in possession of numerous basic techniques for dealing with atomic energy problems. In addition, we have well-equipped research establishments broadly financed and charged with nuclear development.

The specialist is often loth to commit himself until his case is certain, but those responsible for technical planning must think in terms of probabilities, not certainties. Progress has so often depended on faith in the unproven, and those who wait for proof are often left behind.

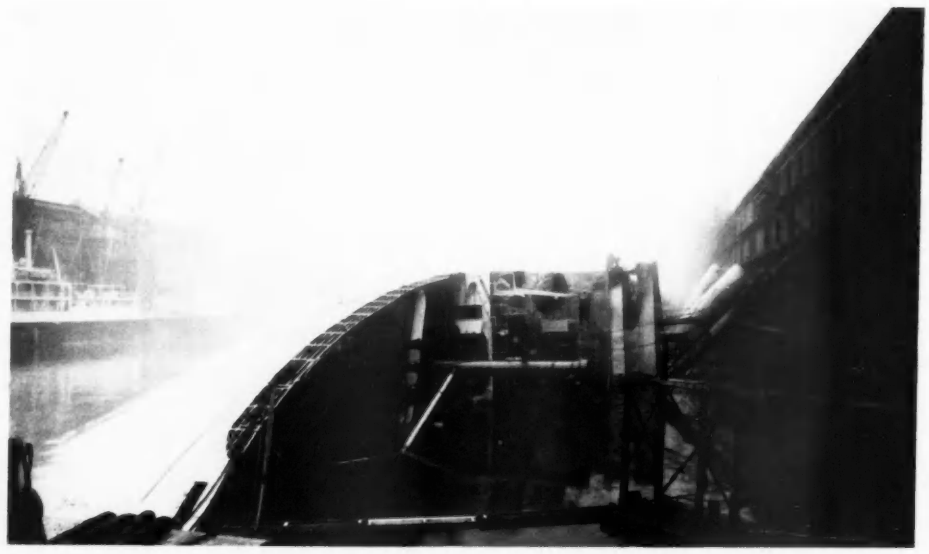

Fig. 1 S.S. Empress of Canada capsized at Gladstone Dock after the fire.

SALVAGING THE EMPRESS OF CANADA

The 29th Thomas Lowe Gray Lecture was given recently before the Institution of Mechanical Engineers, on "Salvaging of Ships with Special Reference to the Empress of Canada," by Captain W. R. Colbeck, R.N.R., marine surveyor and water bailiff to the Mersey Docks and Harbour Board. We give below a summary of the main part of the written paper dealing with operations on the Empress of Canada.

On the afternoon of Sunday, January 25, 1953, the s.s. Empress of Canada (Fig. 1, above) was lying in No. 1 Branch, Gladstone Dock, Liverpool, when an outbreak of fire was discovered in the passenger accommodation, on B deck. By the time the fire brigade arrived, 2 minutes after the alarm, the fire was spreading aft and upward with such rapidity that all that could be done was to attempt to "box" it.

The ship developed a list to port, which increased steadily as did also her draught aft, and eventually the masts and funnels came into contact with the dock shed and she finally sank on her side.

Subsequently, it was found that the cause of the steady increase of list was that the port oil fuel filling door on D deck level was open, providing an aperture 3 ft. by 2 ft. 3 in.

The Empress of Canada was launched in 1928 and, in view of her age and the damage she had sustained, it was probable that she would be a constructive total loss when salved. She was blocking a valuable berth, but it was also important in planning her removal to cause as little interference as possible with the remainder of berths in the dock. The alternatives were to cut her up where she lay or to upright and refloat her. The greater part of the cutting would have had to be done by divers, taking probably some three to four years on the work because of the lack of visibility under water.

It was decided therefore to upright the vessel and then refloat her. Preliminary calculations showed that a total uprighting moment of about 350,000 ft.-tons would be required initially, decreasing as she turned and becoming zero at about 45 deg., and detailed planning to provide this force proceeded.

Meanwhile work proceeded on the removal of the masts, funnels, bridge, deckhouses, lifeboats, davits and cargo winches, each item being listed and weighed after removal. Over 50 per cent. of this material had to be cut away under water by divers working in very low visibility.

The uprighting moment was obtained by using: (1) 16 shore purchases each nominally 100 tons, pulling on wires led over tripods erected on the starboard side of the vessel; (2) 11 salvage pontoons submerged along the port deck edge; (3) six salvage pontoons partly filled with water as counterweights along the

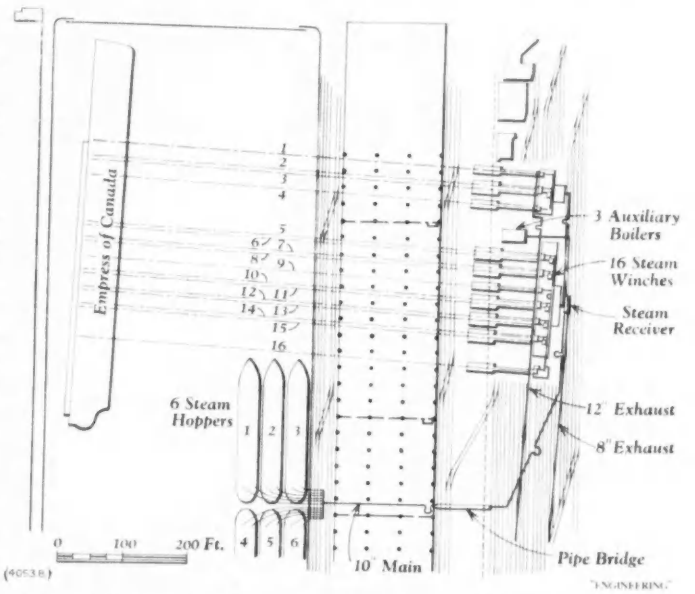

Fig. 2 The general arrangement of winches and wires for righting the vessel.

starboard bilge; and (4) the internal buoyancy in eight compartments in the hull.

To enable the berth to remain in use as long as possible, the anchorage for the purchases and seating for the winches was sited in rail sidings about 150 ft. south of the shed, on the south quay of No. 1 berth; the positions of the tripods on the wreck and the anchorage of the purchases being arranged so that the lead of the hauling wires was at right-angles to the wreck and clear of the shed pillars. The arrangement of the winches and wires is shown in Fig. 2.

Three reinforced concrete blocks were constructed to anchor the purchases and provide seating for the 16 steam winches, arranged in groups of four, eleven, and one respectively.

In the design, a pull of 120 tons on each a 9 in. wire pendant, 60 ft. long, which in turn was shackled to the main wire. The travel of the moving block was limited to about 75 ft., which would produce an alteration in the angle of heel of the wreck of about 45 deg. Since at this list the wreck would still require power to move her towards the upright position, the 60 ft. pendants enabled the purchases to be fleeted out and reshackled to the main wire, as necessary, during the operations.

The hauling part of the purchase wire ran from the outer block to the winch barrel. The main 9 in. wires were led across the dock over the heads of the tripods and secured at the base of the vertical leg of the tripods.

The distance from the heads of the tripods to the rear face of the concrete anchorage varied from 708 ft. to 735 ft. The total length of 9 in. wire was about 11,000 ft., and 24,000 ft. of 3½ in. wire was required for the purchases.

Sixteen welded steel tripods (Fig. 4) were constructed on the starboard shell plating, four single and six double. The vertical leg of No. 1 tripod was at A deck, the remainder being at the promenade deck. Eleven Admiralty salvage pontoons (A.S.P.s) were secured at the port side of the deck close to the dock bottom, providing an upward buoyancy force of 880 tons.

These pontoons are cylindrical in shape, each 33 ft. long by 13 ft. diameter, subdivided by internal bulkheads and fitted with connections for blowing and venting. When fully submerged and blown they have a buoyancy of 80 tons each. They are fitted with a tube passing through the

Fig. 3 The purchases, standing blocks and pendants.

Fig. 4 The tripods on the starboard side, looking forward.

purchase was allowed. The blocks were roughly wedge-shaped in section, being 12 ft. deep at the rear end, 6 ft. deep in front, and with a 2 ft. base step 16 ft. from the front; the centre of gravity being 1 ft. 6 in. off centre towards the rear. The maximum ground pressure when at rest was 0·869 tons per sq. ft. at the rear edge and, under full load, it was 0·941 tons per sq. ft. at the front edge. The tendency was for the block to slide about a slip circle of approximately 54 ft. radius, giving a factor of safety of only 1·17, taking the shear of the soil at 0·1 ton per sq. ft. Larssen sheet-steel piling 30 ft. long was accordingly driven in front of the blocks throughout.

Trenches were excavated to provide a passage for the anchorage pendants to tunnels in the block sloping from the roadway level to a depth of 5 ft. at the block.

The heaving power was provided by the 16 steam winches, of nominal 12 ton pull, loaned by the Admiralty. The main steam supply was from six of the Board's dredging craft moored on the south quay, capable of supplying 120,000 lb. of steam per hour at 180 lb. per sq. in., supplemented by three portable oil-fired water-tube boilers, supplying 5,000 lb. of steam per hour.

The steam from the oil-fired boilers of the moored vessels and the supply from the portable boilers were connected to the same receiver of 380 cub. ft. capacity. When heaving, the stop valves at the winches were fully opened, and the steam supply was controlled from the main valve at the receiver to ensure that the pull of all the winches was balanced as far as possible.

The 3 in. exhaust pipes from each winch were led into a common exhaust line exhausting to air at a distance of 250 ft. from the most westerly winch, in order to keep the steam clear of the operating area.

Each purchase comprised a pair of six sheave blocks rove with 3½ in. circumference steel wire rope. The rear block was shackled to a 9 in. steel wire pendant 100 ft. in length, passing through the tunnel in the concrete anchorage and secured at the rear face (Fig. 3).

The outer or moving block was shackled to

Fig. 5 Counterweighted buoyancy pontoons assisted in righting the vessel.

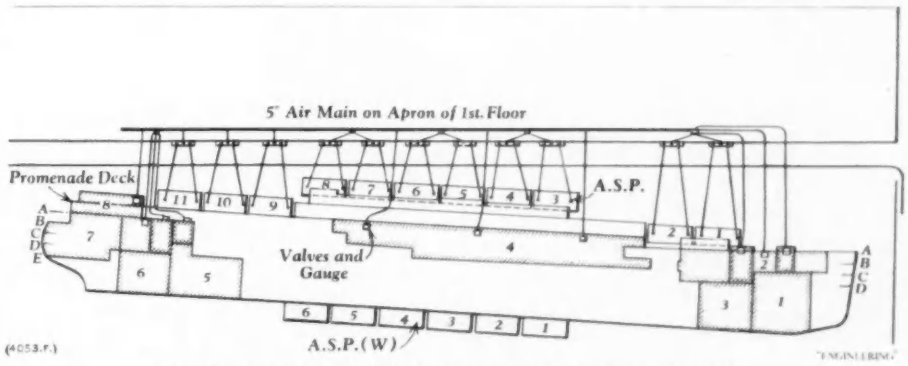

Fig. 6 Arrangement of buoyancy compartments and pontoons.

diameter about 8 ft. 6 in. from each end to take the securing wires or chains.

Five pontoons, two forward and three aft, were secured by wires passing right round the hull from the port deck edge round the bottom and up to the starboard side.

With the six pontoons in way of the boat deck it was not possible to pass the securing wires right round the hull, so the bight of each wire was led through a heavy shackle in a 6 in. wire strop round the base of a Welin boat davit on the port side, the wire then leading up the face of the deck to the starboard side.

Six A.S.P.s were suspended on the starboard bilge (Fig. 5). They were partially filled with water to bring them to the weight of 115 tons each, giving a total of 690 tons, and were positioned and ballasted so that they would float clear when the vessel reached an angle of 50 deg. to the vertical. The required buoyancy was attained by the use of compressed air. Eight separate compartments were made airtight as shown in Fig. 6.

With the water expelled down to the centreline of the ship, a total buoyancy of 4,700 tons would be obtained from these compartments at an air pressure of 6 lb. per sq. in. This buoyancy, in conjunction with the other forces, provided a total uprighting moment only about 5 per cent. in excess of the original estimated required moment and, for this reason, all spaces were made tight to a level about 9 ft. below the centreline, providing an additional 3,900 tons of buoyancy at a pressure of 10 lb. per sq. in.

As the wreck altered its angle to the vertical, air would spill and the compartments reflood in the later stages of the operation, thus preventing the presence of excessive buoyancy when the vessel was upright.

Compressed air was admitted to the compartments through valves bolted to the starboard side, release valves and individual gauges being fitted for each compartment. The gauges could be read from the central control position.

Compressed air was also used to minimise the suction between the mud and the ship's port side in the initial movement. To introduce this air, the divers shot a number of " Temple Cox " air bolts through the port shell plating from inside the ship at D and E deck levels, each bolt being individually supplied by a hose from the quay; in addition, a number of open-ended air hoses were placed by divers between the shell plating and the bottom.

To supply the compressed air, a 5 in. bore pipe was laid on the first-floor apron of the dock shed, with 2½ in. connections to the pontoon control panels, individual connections operated from apron level to the eight buoyancy compartments and connections to the anti-suction fittings.

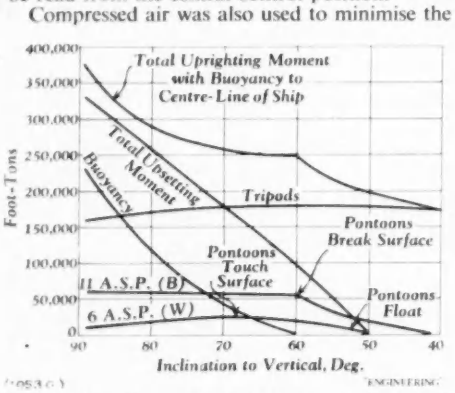

Fig. 7 Upsetting and uprighting moments plotted against angle of list.

Fig. 8 Hauling operations under way—list reduced to 77 deg.

The compressed-air main was supplied from a battery of 14 portable compressors in the shed and additional connections were made to the compressors on the two salvage vessels in case a larger supply was required.

The upsetting moment and the uprighting moment from each of the uprighting sources was calculated for each 10 deg. up to 40 deg. from the vertical, when the vessel had an uprighting moment of 97,150 ft.-tons, the upsetting moment becoming zero at 50 deg. The results of the calculations are plotted in Fig. 7.

The centre of the tripod pull was 6·6 ft. forward of the longitudinal centre of gravity, thus giving a moment tending to twist the wreck horizontally. The pressure on the port shell plating in contact with the ground was estimated to be 0·8 ton per sq. ft., which appeared to be a reasonable ground pressure to resist twisting or sliding on the initial pull. As an additional precaution, three wires 4 in. in circumference were secured at each end of the vessel about 180 ft. each side of the centre length at the deck level on the starboard shell plating, passing right round the hull under the ship and secured to bollards on the quay side.

All work on the wreck, including the testing of the air compartments and the placing of the buoyancy pontoons, was completed by the end of February.

From the main control position on the north quay, all the tripod wires could be sighted and the gauges on the air compartments read with binoculars.

A large pendulum with a scale graduated in degrees was erected on the starboard side forward of No. 1 tripod and observed from the east quay, the readings being telephoned to the central control.

To ensure simultaneous action by the individual winch operators, a revolving order board was erected on the south side of the south shed, in a position clearly visible from all the winches, orders such as " brakes off," etc., being painted in letters 2 ft. high and operated on telephoned instructions from the officer-in-charge at the main stop-valve.

The order to start heaving was given at 12.35 hours on March 6 and the wreck commenced to turn steadily as soon as the wires tightened (Fig. 8). On reaching an angle of 45 deg. heaving had to be stopped as the purchase blocks had come together. No. 7 purchase was overhauled, the 9 in. pendant unshackled and the outer block connected to the main wire, and heaving with this one wire recommenced. The wreck started to roll again, with a pull of about 80 tons, finally coming to rest at 9 deg. from the vertical. The six buoyancy pontoons amidships had now been lifted out of the water and, as their weight was opposing the uprighting force, they were released.

Fig. 9 The Empress of Canada leaves Liverpool after salvage.

As soon as the hauling wires were removed, a grab dredger removed the mud from alongside the starboard bilge, and two " camels " were moored under the tripods and secured to the tripod heads. By flooding the tanks of the camels a weight of 800 tons was applied and the list reduced to 5½ deg.

To avoid a serious risk of the vessel again capsizing, she was ballasted to a refloating draught of about 44 ft., which would give a period of six to seven days during neap tides when the dock water level could be maintained at that height, giving ample time for correcting list and trim before drydocking.

The lower holds and E deck were kept flooded to the lower side of D deck, with the engine room and boiler room flooded at the same level. By keeping the water level 2 ft. above D deck in the hatch trunks and sealing off the whole of D deck, the calculated metacentric height was 8 ft., giving a reasonable margin for eventualities. The only large area of free surface was in the engine and boiler spaces.

To correct the trim and to counteract the anticipated list to port, 2,000 tons of washed gravel were placed in B and C decks on the starboard side aft to give a draught of about 43 ft. 6 in. on an even keel. The tripods were left in position and four empty pontoons were placed on the tripods for the initial refloating attempt.

A pendulum 18 ft. in length, terminating in a heavy plumb-bob with a pointer, was placed on the promenade deck amidships, the deck being marked out so that list and trim could be read directly, this central control position being linked by temporary telephones with the various pumping stations.

On the initial trial it was found that there was an excess of weight to starboard. The pontoons were lifted off and the tripod legs burnt through and the tripods removed.

On June 27, 17 months after she sank, the vessel was refloated with a list of 2 deg. to port and trimming 2 ft. by the stern. By the removal of 200 tons of the ballast, and adjustment

of water levels, she was brought to an even keel on a draught of 42 ft. 1 in. with a list of 1 deg. to port.

In the early hours of July 1 she was towed to the graving dock and landed on the blocks. The examination of the hull showed that the only damage caused in the uprighting had been to the port bilge keel, 60 ft. having been torn off and the remainder bent back flat against the shell plating. In Fig. 9 she is seen leaving Liverpool after salvage was completed.

Letters to the Editor

AN ENGINEER'S CARD INDEX

SIR, Mr. R. Silvester's letter in your issue of January 11, page 38, interests me because, like him, I have long realised the advantages which are to be gained from collecting all kinds of data, that are of potential interest for one's work, in the form of a personal card index. For this purpose, I prefer to use cards of the 5 in. by 8 in. size, as these are large enough not only for the writing or typing of bibliographical references to articles and books but also of longer notes; or to have cuttings, such as abstracts, pasted on them. What is quicker and more flexible than pasting? I also interpolate pockets among the cards (cut to the same width as the cards from old file covers, folded in two from the bottom and having each end closed with wire staples) in which miscellaneous material, such as reprints of articles, newspaper cuttings, advertisements, photographs or small pamphlets, can be inserted. Quarto sheets of typing paper, when folded in two, are the same size as these cards and so can be filed among them if desired: as also can sheets torn from the octavo correspondence pads which are so convenient for carrying about. Anything too large to be folded and put into such a pocket is filed elsewhere under a reference number, and this is written on a card in the index.

In this way, it is possible to accumulate, in a place where one can rely on finding it, a mass of the most miscellaneous material, constituting, at one's finger tips, a sort of extension to one's natural memory. It is much more accurate than the latter as regards detail and is almost unlimited in its capacity. On the other hand, the index is not spontaneous in action: its contents do not automatically present themselves to one's consciousness just because one happens to be thinking about something to which they might be relevant, but a search has to be made for what is required.

How far this disadvantage can be mitigated depends on the efficiency of two things: the system of classification adopted and the provision for cross-referencing. Mr. Silvester touches on the first of these questions and, up to a point, I agree with his ideas. That is to say, I consider that, for the personal purpose described in the preceding paragraph, the classification system should reflect as far as possible the pattern of ideas which exists, or rather which is in process of taking shape, in one's own mind and is the basis of one's own working habits. The case would be different if one were organising an information service to cover other people's needs, since such a service would call for a classification conceived from a more corporate point of view.

But the system of classification adopted seems to me to be of relatively little importance compared with the need for a system of cross-referencing; a necessity which Mr. Silvester does not mention. To make up an example in his own field: what does he do with a reference to a comprehensive report on a tidal-power project which, incidentally, but usefully, describes a series of experiments on models, the new techniques invented in the course of conducting these experiments, advances in the theory of sediment movement developed for the purpose of interpreting them, and details of many other estuaries tabulated for the purpose of comparison with the one under investigation? There may be any number of these multiple aspects of interest, but if all of them are mentioned in an abstract of which he has only one copy he cannot file it in more than one place. The choice of the particular aspect of interest to put the copy under will often be arbitrary and the only way to make sure of retrieving it, in the event of information being sought on one of these other aspects, is to put in cross references from those aspects. How does he achieve this cross referencing without spending more time than is justified on something which there is only a small chance of his wanting?

Personally, until a year or two ago, I used to classify such of my cards as referred usefully to more than one subject in accordance with what seemed prima facie to be the most important subject from my own point of view. I secured this result by using what I called "ramifying key-words," arranged in alphabetical order; the principle being that each of these key-words described a further particularisation of the idea described by the one on its immediate left. If a reference card related also to other subjects besides the one described by the string of key-words under which it was classified, I identified the card by attaching a signal of a given colour in a given position on its top edge and I inserted cards under the other relevant subject headings; on each of these cards I simply marked an arrow-head in the same position as the signal on the reference card, writing alongside the arrow-head the initial letter under which this reference card was filed and the colour of the signal. Inserting these arrow-head cards takes very little time and their effect is that one is led to the wanted information with almost the same speed regardless of the heading chosen for filing it under. This system and others—including the Universal Decimal Classification, which is designed for corporate use—are described in Part II of my book, *Facts, Files and Action* (Chapman and Hall, 1953).

Latterly, however, I have changed over to another way of achieving the same result with even less trouble. I do not now classify my cards and card pockets by subject at all. Instead, I file them alphabetically under authors, followed by the years of publication, like HARKER 56 (or, if there is more than one author of that name, HARKER, P. J. 56). Besides doing that, I keep an indexing book (a thick address book) in which I enter, in strict alphabetical order, but always leaving very ample space for later interpolations, catch-words or short descriptive phrases designating all the subjects of possible interest to me that have been touched upon on the reference card. Each catchword or phrase is followed by HARKER 56 so as to direct me to that reference in the file of cards. Items of information which have no stated authors are filed and indexed as A56/1, A56/2, etc., in arbitrary numerical order. The bane of alphabetical indexing is the occurrence of synonyms and, what may be still more troublesome, of near-synonyms, but this difficulty can be minimised by adopting the simple rule of always following one's own precedents rather than introduce new words. It is useful to tick off on any of the cards those words which have been used as index entries.

This method is crude, but it works and takes up very little time. It has the further advantage that when one is too busy, or cannot be bothered, to do the subject indexing at the same time as filing a new card, one can at any rate be sure of finding the card if one remembers the author's name and, until one does find time to complete the indexing, one can put a temporary signal on the card drawing attention to the fact that this little job remains outstanding.

I should make it clear that these remarks are offered in my private capacity, but Unesco is actively concerned in questions of information storage and retrieval by all methods and I consider that Mr. Silvester has done a service by referring to these matters from the point of view of the individual engineer.

Yours faithfully,
J. E. HOLMSTROM,
Department of Natural Sciences.
United Nations Educational, Scientific and Cultural Organization,
19 Avenue Kléber,
Paris 16e.
January 14, 1957.

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PIPE-LINE CALCULATIONS

SIR, I read with interest Mr. F. Baker's criticisms in your issue of December 21 (page 774) of my article, "End Reactions and Stresses in Pipe-Lines," and his resulting conclusions. I thought that I had made it clear in my introduction that this approximate method will be of special use to people who are not regularly employed on this type of work. There is no doubt that in a drawing office primarily concerned with piping layouts, a recognised tabulating method, or better still, the employment of an electronic computer, will certainly cut down the calculating time and hence reduce the saving in design time achieved by the simplified method. Nevertheless, I very much doubt whether the use of the elastic-centre method will enable anybody to produce the answers for a three-dimensional pipe-line system to operate at 800 lb. per sq. in. between a boiler and a primary turbine in two hours.

It is not quite clear to me what Mr. Baker means by saying that "it is incorrect to suggest that the proposed approximate method will yield results comparable with those of an accurate analysis." I can only refer him once again to my summary which is based on 23 different piping problems and which shows the variations in the magnitude of forces and moments (stresses) when compared with answers from accurate methods. For three-dimensional pipe layouts the differences in the value of the maximum forces as between the proposed method and the accurate method were + 15 per cent. and − 14 per cent., and the corresponding maximum moment differences were + 7·5 per cent. and − 15 per cent. in 8 cases. I would like to reiterate once more that in the two three-dimensional problems in which both an accurate method and its "square-corner" approximation were used, the resulting thrusts varied by − 18 per cent. and + 9 per cent. and the maximum bending moment by − 12 per cent. and + 4 per cent.; the errors thus incurred were in fact comparable with those obtained by the simplified method.

Although, in two of the three examples cited in my article, the maximum stresses are in fact *over-estimated* (by 2 per cent. and 5 per cent. respectively; the under-estimation is by 12 per cent.) it is, of course, quite obvious that allowance would have to be made for some under-estimation of stresses if one bore in mind the values that might be obtained by an accurate method, which in itself, of course, is based on certain assumptions which may or may not be correct. In all the layouts dealt with by me, this problem never arose. Most firms have standards of piping dimensions for certain pressure and temperature conditions and, given a reasonably flexible layout, which is largely a question of experience and available space in any case, it is now largely a case of ensuring that the maximum allowable working stress is not exceeded by the calculated maximum equivalent stress. There is nothing to prevent anybody, bearing in mind that a discrepancy of up to approximately 20 per cent. in values between the two methods may occur, of employing, at this stage of doubt, an accurate method if the two stresses are so dangerously close to each other. It is, therefore, most unlikely that the use of a simplified method will lead to an increased cost of piping.

Yours faithfully,
L. F. RANDOLPH.
Imperial Chemical Industries, Limited,
Billingham Division,
County Durham.
January 16, 1957.

Weekly Survey

Cover Picture: *Gear cutting is increasingly becoming the work of specialists, from the manufacture of precision gears for instruments and watches to the production of heavy-duty gears such as the single helical pinion shown in the illustration. The pinion, which is of high-tensile nickel-chromium oil-hardened steel, is seen being cut on a universal hobbing machine employing a form-ground hob and will be used in a coal pulverising plant for an electrical generating station.*

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Armament Cuts

There is every sign that the new Government intend to reduce expenditure on defence by 25 per cent. or more. In one of his first public speeches the Prime Minister made it clear that he wanted to make large cuts, of the " things we don't need and developments we can't sustain." This means rather more than has been announced so far, such as the reduction of manpower reserve, the lapse in training of reservists and lopping off 100 from the order list for the Hunter fighter. These measures were envisaged by Sir Anthony Eden's Government and go only a small distance towards Mr. Macmillan's objectives. The wish to participate in European free-trade (discussed in another note) and the conviction that this country's only hope of continued prosperity lies in heavy industrial investment both require savings in unproductive expenditure. Defence expenditure must be brought down at least to the level of that of our principal European competitors. The cuts announced so far—which may save about £20 million a year—are simply a removal of some " out-of-date " defence measures and weapons. More cuts are expected in manpower reserves and weapons that have been made obsolescent by developments in nuclear warfare. Reductions in overseas commitments are also likely. The Defence White Paper, which will be published next month, is likely to contain a new plan for defence and a revision of Britain's commitments. The logical consequence of such a policy is the abolition of conscription, or its replacement by a selective call-up.

The reduction of orders for the Hunter will be painful for the factories concerned. Further streamlining of orders for fighters is likely; on the other hand, the Government cannot be expected to order large quantities of guided missiles for stock. The offer by the United States to supply the latest guided missiles in order to help in the reduction of military expenditure may, if accepted, obviate the need for any but small-scale production. The implied gradual conversion of the British aircraft industry to non-military work is likely to be one of the major structural changes in British engineering during the next two or three years.

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" We are Competitive or we are Nothing "

The words spoken by the new Chancellor of the Exchequer, Mr. Peter Thorneycroft, to the American Chamber of Commerce in London last week are a suitable introduction to a review of recent moves and counter-moves in the great controversy of the European Common Market: " We have recently taken the lead in proposing a free trade area for Western Europe. Not for a bit of Europe but for all Europe which will reciprocate in the abolition of tariffs on manufactured goods. I want to make it plain beyond peradventure that this Government is solidly behind the scheme and those proposals . . . In Britain we are competitive or we are nothing. I know of no economic theory which would enable us to survive in any other way." Mr. Thorneycroft made his point and there is now no room whatever to doubt that he and the Prime Minister are firmly resolved to create a European market of 250 million people, which can give to Europe the strength to become an area as prosperous and as powerful as any in the world.

Mr. Macmillan and Mr. Thorneycroft will not be lacking for critics—within their own party even more than outside it. Already they are accused of playing a dangerous Commonwealth gambit. Their task now is to reassure those who believe the present Government to be hypnotised by " the new and exciting prospect " of European trade to the extent of forgetting the other side of the picture, the Commonwealth and the system of preferential tariffs that proved the lifebelt of inter-war Britain. This will not be easy, despite the Chancellor's assurance that it remains " firm and enduring and exciting too." Nonetheless, the Government have pledged themselves against restrictive rings, " arrangements which keep everybody, even the least efficient, in the game." The same must apply to import quotas, preferential tariffs and other barriers to trade. The argument is that the stronger Europe grows industrially and commercially the better it will become as a market for the rest of the world, the cheaper it will be as a source of supply and the more able to provide capital for countries which require it. The argument is hard to refute, but in the process of economic integration which is involved there will be casualties and some will be British, including some in the engineering and metal industries. The situation will require much of the " skill, grit and determination " Mr. Thorneycroft rightly says is the hallmark of British enterprise.

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Increased Exports to Australia ?

The expected relaxation of Australian import restrictions has been announced rather earlier than was expected and will provide a welcome stimulus to exports of certain engineering products in 1957. The relaxation has been made possible by an improvement in the Australian trade balance of about £A100 million in the first six months of the current financial year. Moreover, Australia now has available a further loan from the International Bank of about £A22 million. In comparison with these figures the expected increase in imports of £A30 million a year appears relatively small.

In announcing the relaxations the Commonwealth Treasurer pointed out that the improved trading position in the current year is largely due to favourable wool prices and that Australia still needs to build up her overseas reserves. The present changes in import licensing will not be reflected in increased imports for several months, not until the Government have assured themselves that the country will be able to sustain a continuously higher level of imports.

It is expected that increased import quotas for certain types of textiles will then amount to about £A3 million and that there will also be greater imports of certain chemicals. The main increases, however, are likely to be in capital plant and machinery and in agricultural implements.

The new relaxations are expected to go a long way towards cancelling the effects of the cuts imposed on July 1, 1956, though it does not necessarily follow that they will apply equally over the whole range of industry. The motor industry, for example, was very severely affected by the July restrictions, imports of fully assembled motor vehicles being cut by 50 per cent. It seems probable that in applying the relaxations, the Australian Government will have particular regard to capital development and will postpone increased imports of consumer goods until it is possible to take a longer-term view regarding the Australian trading outlook. None the less, the prospect of further relaxations would appear to be reasonably good since there is every indication that the trading balance for the complete financial year may be the best ever recorded and, by June next, reserves held in London may well be considered high enough to provide an adequate safeguard against short-term fluctuations.

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Progress at Milford Haven

The development of Milford Haven as the major deep-water terminal for large ships is now only a question of time. Last week the Minister of Transport, Mr. Harold Watkinson, announced that a conservancy authority is to be set up by the Government " in relation to the need to make the best use of Milford Haven in the local and national interest." The announcement was made after a meeting of representatives of Milford Docks, British Petroleum, Esso Petroleum and other organisations interested in the considerable development projects that have been put forward. A small committee is to be set up to keep the Ministry of Transport and the Admiralty advised on progress. The conservancy authority will be mainly responsible for keeping navigation free.

Much has yet to be worked out in connection with the schemes put forward so far. There is little doubt that many more schemes have yet to appear. The industrialisation of the area—one of the beauty spots of South Wales—will be strenuously opposed. Yet there is no natural harbour so suitable for large tankers and ore carriers. Already British Petroleum are constructing a tanker terminal and a 60-mile pipeline at a cost of £5 million to feed their refinery at Llandarcy. Esso have a scheme for building a £20 million refinery, with a capacity of 5 million tons a year, to be completed by 1960. The B.P. scheme is scheduled to be commissioned in 1959. Two steel companies—the Steel Company of Wales and Guest Keen Iron and Steel—have acquired a 1,000 acre site suitable for handling very large ore-carriers. Within a few years both oil and ore will be carried in 100,000 ton ships and Milford Haven alone can provide berths for such giants.

Other projects have been put forward by Milford Docks, including plans for more wet and dry-berth facilities. The area is a strong candidate for one of the nuclear power stations envisaged in the revised programme of the Central Electricity Authority. In less than a decade the area could become one of the most highly industrialised in the British Isles.

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Texans Refuse to Co-operate

The reaction of Texan oil producers to the urgent needs of Western Europe has proved very disappointing. Despite successive price increases, independent producers—who account for 58 per cent. of total Texan production—have refused to raise the permitted oil output for February beyond 15 days' production and have turned down the request of four major companies that the quota, known as " allowables," should be raised by two production days. The decision of the Texas Railroad Commission, who are the controlling authority, means that output next month will increase by 93,000 barrels a day instead of the 430,000 barrels suggested by seven of the leading companies. The increase is considered insufficient to enable shipments to Europe to be maintained at present levels. A United States Government spokesman has warned that " stock withdrawals cannot continue much longer."

The main reason for the independent producers' refusal to increase output is believed to be a political one. The Commission considered that so high a demand could not be met without ending the system which equalises output among the various companies. There is a shortage of pipelines to the Gulf coast in West Texas, where the bulk of the State's surplus is. Companies who own no pipeline can gain little benefit from

an increase in "allowables." Moreover, the Middle East crisis has resulted in very high and rising stocks of motor spirit, which threaten the position of the Texan companies. Hence the oft-repeated statement that Europe can have crude provided it takes also a proportion of motor spirit. The lack of co-operation of the Texan producers, and the basis for it, is explained by one of their spokesmen as follows: "This is not an emergency. We don't want to rush in and supply oil for the convenience of a few companies—and find ourselves in a worse position when the crisis ends." Meanwhile, prices continue to rise. The cost of bunker "C" fuel oil has risen by 20 per cent. since the Suez Canal was blocked. An increase of 15 per cent. was announced last week.

To the British and Western Europeans this is a galling situation, which further underlines the political risk attached to oil and must add conviction to those who believe nuclear power should have chief priority. In the short term the possibility of getting the damaged pipelines in Syria flowing again (the Iraq Petroleum Company announced that it could be done within a week of starting repairs) offers the best hope of an improvement. The I.P.C. stated that 11 million tons a year (40 per cent. of normal) could be obtained, reducing Europe's shortage by one-third.

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G.E.C. in 1956

Over the next few years the development of atomic energy will account for an increasing proportion of the activities of the leading companies in the electrical engineering industry. In a review of the activities of the General Electric Company in 1956, pride of place is given to the order, announced on December 13 last, placed by the South of Scotland Electricity Board with the G.E.C.—Simon-Carves Atomic Energy Group, for building the world's largest atomic power station. It is claimed that the contract for this 360 MW station probably exceeds in value and scope any other single contract hitherto placed with a British industrial organisation. Another contract in this field was for a 15 MW turbo-generator for the Dounreay nuclear station of the Atomic Energy Authority to utilise the heat from the fast-breeder reactor.

The atomic energy and guided missiles programme is also giving rise to a number of interesting ancillary orders. Among these, the review mentions a high-temperature furnace capable of reaching a temperature of 3,000 deg. C. which has been installed at the Atomic Research Establishment at Harwell. It has been built to assist experimental studies of making graphite.

In the export field the company has received important orders for mining and materials-handling equipment. Three crushing and washing plants are to be installed over the period 1958 to 1960 for exploiting a manganese ore deposit in British Guiana, and a new iron-ore concentration plant is to be supplied to the Sierra Leone Development Company at Marampa. For East Africa, the company is to supply an ore-stocking and reclaiming plant comprising a stocking bridge and drag scrapers. G.E.C. have also obtained important orders in connection with the extension of industrial capacity in India. These include a contract for main and auxiliary motors, converting plant, power rectifiers and control gear for a 15-stand Morgan continuous merchant mill at the Durgapur steelworks, in addition to large quantities of motors and control gear for other sections of the works.

At home, apart from atomic energy, an increasing volume of work was secured in connection with railway electrification and signalling, while the supply of conventional generating plant at just under 500 MW constituted a company record in 1956. The firm is well assured of a high level of activity for some time to come.

Coal Profit in Prospect

It is expected that the results of the National Coal Board for 1956 will show a net profit of at least £10 million after all charges have been paid. This forecast was made by Mr. James Bowman, chairman of the N.C.B., last week. It should make a useful contribution towards reducing the accumulative deficit which stood at £37 million at the end of 1955.

He also reaffirmed the Board's undertaking to keep prices stable until June. He was non-commital, however, about what might happen after that date. There is, of course, every reason for him not to commit himself, for the cost of steel and fuel have gone up and the miners have formulated a new wage demand. It seems likely that the better results in 1956 will have been gained with only a modest increase in output. The expected total of coal mined last year is about 211 million tons which will be only 1 million tons more than in 1955.

There is some evidence that the Government's deflationary policy has had a useful effect on mining recruitment. Total recruitment at 65,500 was the best since 1952, while the total manpower increased during the year by 3,500, a good deal of this having been brought about by short-time working and redundancy in other industries. There is, however, still a shortage of about 9,000 men at the coal face and the N.C.B. is confident that it can absorb all British workers who present themselves for a job—as well as Hungarian refugees. Mr. Bowman said that any impression that Hungarians would take jobs which should go to British workers was unfounded.

As regards productivity, progress in the industry is still slow. In 1951, when manpower was slightly lower than it was in 1956, a slightly larger tonnage was raised. In the intervening five years the main developments in the industry have been the continuing high level of capital investment and the improved wages and working conditions of the miners. The country is gradually changing over from a cheap to a dear-coal era and the industry is getting both the investment and the social benefits of such a policy in advance. The signs are not encouraging that this policy of putting the cart before the pony is going to produce a higher tonnage of coal any more quickly in the future than it did in the past.

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Another Year of the Colombo Plan

From the birth of the Colombo Plan in 1950 to the middle of 1956 about £850 million has been given from external sources to countries benefitting under the arrangement. Over the same period the International Bank has lent £128 million. The total figure is thus in the region of £1,000 million. So far as this country is concerned, the main channel of capital assistance to the Colombo Plan area is through private enterprises, but the United Kingdom Government has made substantial grants as well and Asian countries have been allowed to run down their accumulated sterling balances to pay for capital equipment. This country has also sent 205 technical experts to the area over this period—possibly one of the most precious exports of all at the present time.

In its latest report (just published, H.M.S.O., 5*s.* 6*d.*) the Consultative Committee continues to be confident of the value of the Plan and the prospects for solving its problems in the future. Progress is reported in irrigation schemes and the output of electric power for the area as a whole. As always, it is concerned about the immensity of its problems. Planning the allocation of scarce resources of technicians and capital over such a huge population necessarily calls for great flexibility. Such hazards as drought, flood and crop failure are not uncommon occurrences, and they can seriously affect the co-ordination of plans which have necessarily to be prepared on a long-term basis. Under such circumstances the margin of error is large and major difficulties arise in keeping the rate of development in the different parts of the area in step with one another. Social plans loom large in the area and basic thinking has to be undertaken about the best way to employ huge populations which are moving slowly but inexorably away from subsistence economies based on primitive agriculture to an elementary form of industrialisation. It must clearly tax the ingenuity and experience of the authorities to achieve the correct rate of expansion of such basic services as power, improved communications and clean water against the clamant demands from the people on the spot for ambitious social schemes and secondary industries.

So far, capital from abroad has been mainly in the form of grants but, according to the report, if the tempo of expansion is to be maintained, private foreign investment may have to play a larger part. As this need develops, the problems of the Colombo Consultative Committee will move increasingly into the political sphere. When this becomes apparent the difficulties of the members will become more acute. In the end, no matter how good and orderly a start to industrial development the Colombo Plan provides, the countries of Asia have got to establish conditions under which capital and technicians can be attracted from other parts of the world, notably the West, which have their own ambitious plans for increasing their own standards of living.

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Electrical Traction Equipment

At an earlier stage of 50-cycle traction development, considerable importance was attached to the possibility of using standard industrial squirrel-cage motors for auxiliary drives. Locomotives were equipped with single-phase/three-phase converters for these supplies, the machines usually being used to drive the direct-current generators for battery charging. A typical example of this system was seen in the first 50-cycle C_0-C_0 locomotive for the French National Railways, which was built by the Swiss Locomotive and Machine Works and provided with Oerlikon electrical equipment. Opinion in France is now tending to prefer direct-current auxiliary machines fed through rectifiers, and this is reflected here in particulars released of multiple-unit stock to be equipped for the 25 kV 50-cycle system under the contracts announced last week by the British Transport Commission.

Auxiliaries will be more numerous than in direct-current equipment. The G.E.C. scheme for the Enfield, Chingford and Bishop's Stortford stock, for example, includes forced oil circulation for the transformer, forced circulation of the rectifier cooling liquid, and forced ventilation of the smoothing chokes, apart from the usual battery-charging equipment and compressor. Recent years have seen much improvement in the capacity of dry-plate rectifiers, which are being used in industry for a growing range of purposes for which previously motor generators were required, and it is probable that in motor coach stock individual units will be used for each direct-current drive. In locomotives, where the space problem is less pressing, the solution may be to use a mercury-arc or semi-conductor rectifier, of the new and compact types being developed, to supply a group of auxiliary drives. At the same time attention is being given in France to reducing the auxiliary load, particularly for cooling, and a proposal has been made for mounting traction motor blowers in the bogies to reduce the amount of ducting, advantage being taken of the higher operating temperatures possible with Class H insulation.

The total value of British Railways contracts is £8 million, which is for the supply of equipment to the Glasgow suburban lines, the Manchester-Crewe section, the London-Southend section and the Chingford-Enfield section. For the most part the mechanical parts of the trains are being supplied by British Railways workshops,

while various leading electrical firms are supplying the electrical equipment.

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Railway Diesels

The Diesel engine has come to stay as a power unit for the railways; certainly in the railcar and in the shunting locomotive form if not for express main line work. British Railways are well aware of what this means to them, and a paper given by Mr. T. F. B. Simpson, manager of the Derby Locomotive Works, to the Institution of Locomotive Engineers, shows they are getting down to the business of constructing and maintaining these locomotives. It is proverbially difficult to teach an old dog new tricks, and the new Diesel engine must certainly appear to be a real box of tricks to those who have been brought up for years in the tradition of steam. Nevertheless, the new power unit has been accepted, and is being competently handled. Although some room for criticism might be found by Diesel engine purists in the methods of testing that British Railways have developed, and they might also feel that more advice could have been obtained from those manufacturers who are well versed in the production of both Diesel engines and electrical equipment, yet the preparations made at Derby certainly seem to be adequate to handle the repairs and maintenance required.

The paper refers to methods that have for long existed in the railway shops. Remarks about open flame lamps and cotton waste are illuminating in more senses than one. Also well brought out in the paper is the remarkable reliability of the Diesel locomotive, particularly in the shunter form. It is probable that experience on main line stock is not yet sufficient to judge the reliability of this type, but there seems to be no reason for supposing it would be any less than with shunting locomotives. Experience with Diesel railcar units is also as yet insufficient to make a full judgment on reliability. Although by automobile standards the limits of wear permitted on some of the parts are large, yet no one could really quibble on an estimated cylinder liner life of twelve years, with an estimated wear during that period of 0·025 in. General overhauls are undertaken on shunting locomotives at intervals of 80 months, which are equivalent to about 60,000 miles of service, and intermediate overhauls at about half that period. In general, from the information given in the paper, it would seem that the wear on the running gear of a Diesel shunting locomotive is less than that on a steam locomotive.

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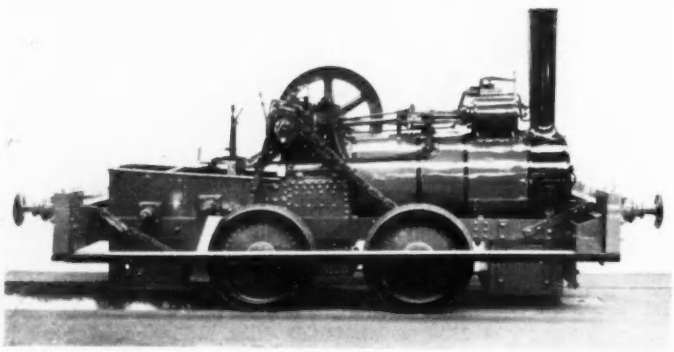
Wotton Tramway Locomotive

The Wotton Tramway was constructed by the Duke of Buckingham and, until its working was taken over by the Metropolitan Railway in 1899, it was subsequently called the Oxford and Aylesbury Tramway, although it never went within miles of either place. Its motive power consisted originally of two locomotives of Aveling and Porter's manufacture. This type of locomotive was obviously a very close relative of the traction engine. It had a considerable vogue from the 1860's onwards and was being built into the early years of this century. Where speeds were low—as was indeed the case on the Wotton Tramway where a running time of 1½ hours was allowed for the 6½ miles—this type of locomotive had certain advantages. The wheel arrangement was 2-2-0 or 0-4-0. Chain drive was sometimes used, as in the example illustrated, where it additionally coupled the wheels; but gears were also employed. It was probably the most accessible form of locomotive ever evolved and it had the attraction of costing only about half as much as the orthodox equivalent. This particular one cost £400 when new.

The considerable number of such engines used in industrial undertakings has dwindled rapidly in recent years and the type is now almost extinct. It was therefore an excellent idea on the part of the Industrial Locomotive Society to acquire the survivor of the Wotton engines from the brickworks in Northamptonshire where it worked from 1894 to 1940, and to arrange with London Transport for its restoration, which has been very well carried out. The idea culminated in a ceremony at the Metropolitan Line Depot at Neasden on January 19, when Mr. A. W. Manser, chief mechanical engineer (railways), London Transport Executive, accepted the engine on behalf of the British Transport Commission from Mr. G. Alliez, chairman of the Industrial Locomotive Society. Acknowledgment was made to Aveling-Farford, Limited, successors to the original manufacturers, for their assistance in restoring the engine to what must very closely represent its original appearance.



A locomotive built for the Wotton Tramway in 1866 which has now been restored for preservation.

The boiler has a barrel of Staffordshire plate and a firebox of Lowmoor iron. Figures for heating surfaces are not available, but a similar type of locomotive built in 1866, the same year as the Wotton engine, and described and illustrated in ENGINEERING at that time (vol. 2, page 86), had a tube heating surface of 184 sq. ft. and a firebox surface of 28 sq. ft. The grate area was 7¾ sq. ft. and the working pressure 80 lb. per sq. in. That engine, however, had a rated horse-power of 10 (against 6 of the engine now illustrated).

This is a valuable addition to the historic locomotives possessed by the British Transport Commission. We are aware of the difficulties in properly housing these locomotives but we hope that it will be possible in the near future to make arrangements for at least a selection to be made available for public inspection.

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The Shadow of the Axe

The defence cuts bear hard on the Hawker Siddeley Group who make the Hunter fighter. If, as is likely, the decision means that the Government have decided to abandon the conventional fighter in favour of guided missiles, more shocks may be forthcoming in respect of the Javelin and the Sea Hawk. Sir Thomas Sopwith, chairman of the company, told shareholders recently that "if the defence industry of our country is cut down to very low limits there is the serious danger that our carefully built teams of scientific, technical and production experts will disintegrate. This would be a national tragedy." It would also be a disaster for the company if the cuts were carried out without warning. But, as Sir Thomas points out, the welfare of the group—who employ 75,000 people in this country, Canada and Australia—lies in the direction of diversification "both in the type of its business and its location." One of the major factors in the Group's growth has been the success of A. V. Roe Canada Limited. Formed in 1945 with 300 employees it has now become one of the major industrial units in Canada, employing over 20,000 people in ten establishments.

The lack of a civilian aircraft is a yawning gap in the Group's range of products. Expressing his confidence that a world-wide market awaited the right aircraft in the civil transport field, the chairman mentioned that their subsidiary company, Sir W. G. Armstrong Whitworth Aircraft Limited, are developing a freighter "coach" in which airlines have already expressed strong interest. For a company so large, the extent of the diversification is nevertheless relatively narrow—at least so far as can be gleaned from Sir Thomas Sopwith's report. Most of the major investment schemes mentioned relate to aircraft or guided missile research or development projects: Armstrong Whitworth Aircraft are expanding research facilities at Whitley "in connection with guided missiles and aircraft"; A. V. Roe are expanding their already considerable research facilities and constructing a very high-speed wind tunnel; a special building at Chadderton will be opened this year to investigate the problems of the heat barrier.

Another item of considerable interest in the chairman's announcement is that work is being carried out by Hawker Siddeley Nuclear Power Company "in studies of certain nuclear reactor systems and, in particular, the liquid-metal type of reactor."

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Export Difficulties

Two companies have recently underlined the difficulties they have been experiencing in export markets. R. A. Lister and Company, Limited, who make internal-combustion engines, trucks and agricultural machinery, mentioned "varying forms of restrictions on imports in many overseas markets." Sir Percy Lister, the chairman, said that the growing tendency to encourage secondary production in many of his company's markets, coupled with the closure of some for political or economic reasons, had tended to make competition more intense for what remained. Listers are not alone in this; a number of their competitors have found direct exports, of Diesel engines in particular, more and more difficult. The erratic behaviour of the Australasian markets, the virtual closure of India, and the Middle East crisis have considerably reduced the export sales potential. Listers were fortunate enough, however, to be exposed to only small losses on a large contract from Egypt for pumping units for rural water supply.

Marshall, Sons and Company, Limited, who export about half their turnover, find that "more and more overseas purchasers are seeking some form of extended credit." Their chairman, Mr. Ashley S. Ward, pointed out that some provision for this was needed from the company's own resources but expressed the hope that the Government were aware of exporters' difficulties. Marshalls' products—a wide range of medium to heavy engineering plant and machinery—were in good demand and output was generally limited only by the availability of skilled labour and material.

SOVIET TECHNICAL JOURNALS

THEIR ROLE IN THE ECONOMY OF THE U.S.S.R.

By O. Tedder

It has been said that the literature of a country reflects the character of its people. In the same way, a country's technical Press mirrors its industry. The Soviet technical Press does even more: it provides a true picture of the whole economic system serving that part of the world separated from us by the Iron Curtain.

A careful study of this Press presents a clear picture of the state of development of Soviet engineering, the principles upon which it is established and the difficulties which had to be overcome while adjusting the live organism of the economy to the artificial foundations of Soviet Communism. But there is also much valuable technical information to be gained from Russian technical periodicals, the sole object of which is to contribute to the increase of industrial production.

There is a wide gap in the Soviet economy between theory and practice, between the grand-scale planning, which in a wider sense includes scientific research, and the somewhat less than modest reality as expressed, for instance, by the living standard of the population. This discrepancy, which is mainly due to the low overall efficiency of the economic machinery in all its stages, including the quality of finished products, is truly reflected in the Russian technical Press.

TWO CLASSES OF PERIODICAL

There are two clearly distinct classes of technical periodical in the Soviet Union; there are journals reporting on the results of scientific work carried out at various research establishments and experimental stations, and journals intended for the rank-and-file of the industry with the object of raising output. The first group represents the grand-scale planning, the second the sober reality.

A weak link between these two groups is formed by a few journals such as *Elektrichestvo* (Electricity), *Vestnik Mashinostroeniya* (Mechanical Engineering Journal), and others, which carry on the traditions of journals established before the Revolution and publish more specialised articles in addition to material intended for a wider circle of technicians.

All Russian periodicals are government-owned and follow strictly the Government's directives which in this case are designed to stimulate industrial output. This explains much of the difference between the Western and the Russian technical periodicals and defines the character of the latter: their main objective is to assist in the expansion of the national economy by direct advice and by raising the educational standard of those employed in the industry.

The scientific-technical periodicals of the first group are published usually by the various technical branches of the Academy of Sciences, technical universities and other central research institutions and are financed directly from Government allocations for scientific research. In appearance and content they differ little from their Western counterparts—the various *Transactions* and *Proceedings* of our scientific institutions. The Russian periodicals of this class are well edited, well printed and the material they publish is of considerable scientific value partly due, no doubt, to the favourable working and living conditions created in Russia for scientists and to the ample resources put at their disposal. The practical value of papers regularly published in scientific-technical journals such as *Bulletin of the Mechanical Section of the Academy of Sciences*, *Avtomatika i telemekhanika*, and many others is, on the average, probably even higher than that of those Western periodicals which are usually purely scientific and not intended to be of a practical nature.

The second group of Russian technical journals is formed by a large number of specialist industrial periodicals published by industrial ministries (which correspond to large horizontal industrial combines of the West) and are financed from the funds of these ministries. The journals of this class are usually not so well edited as the scientific periodicals; their paper is often unsuitable for satisfactory reproduction of half-tone illustrations and this affects not only their appearance but also their value. In addition, their articles discuss problems nearer to the shop floor.

A VEHICLE FOR SUGGESTIONS

A substantial proportion of the editorial space of Russian engineering journals is devoted to suggestions from shop floor to shop floor of improvements in design of tools, jigs and fixtures, of improved methods and processes, of ways to reduce material and fuel consumption, and so on. Similar articles by designers and production engineers give detailed descriptions of plants, their elements including design principles, calculation data and operational experience. The amount of detail given in these articles is striking, and the articles usually end with a list of shortcomings of the plant discovered in tests or in operation. This practice is in full agreement with one of the principles of the Soviet system which demands criticism from everybody of everything except the system itself. It represents a feature unknown in the Western press but certainly very useful from the point of view of the readers.

It is not only the completed plants and their parts that are discussed in Russian periodicals. Quite often reports are published on the state of development of new machines and techniques. Reports of this kind are obviously intended to arouse interest in promising new ideas and to attract new people to independent work on the subject. It will be noted in this connection that, apart from matters concerned with defence, there are no production secrets in the state-owned competition-free Soviet industry and many publications contain details which Western manufacturers would have been very reluctant to divulge. No doubt, this liberal exchange of experience and ideas is one of the advantages of the Soviet economic system and contributes a great deal to improving the efficiency of Russian industry.

One of the special features of Soviet technical periodicals is the absence of advertisements, except for those of a few British manufacturers which have been regularly appearing in many large Russian engineering journals for about a year. There is no need for a Russian manufacturer to advertise his products, since there is no open market in the Soviet Union and everything he produces is bought by the state. On the other hand, there is not much for him to choose from; he just submits his wishes to the planning authority and is allocated what they think he needs, from what they have available.

THEORY AND PRACTICE

The division of the Russian technical Press into two distinct groups is not a result of natural development but a by-product of the Party's economic policy. Soviet leaders are well aware of the low efficiency of their industry and the encouragement of scientific research on subjects likely to produce an increase in industrial output is one of the measures taken to improve the situation. It is expected that grants for scientific work are a better investment than the allocation of the same sums to the industry directly.

Scientific work in the Soviet Union is much better paid than work in industry, and even better than corresponding work in Western countries. This, and even more the generous allocations in money, manpower and material, have created for science an artificial atmosphere, giving it conditions far better than those in which industry works. The consequence of this disproportionate distribution of resources is that Russian industry is not able to cope, either in quantity or quality, with the demands made on it, and is unable to apply the results supplied to it by science. Further, it cannot take into production and put into operation all the new machines and processes developed by theoretical technologists; the descriptions of new plants and processes published in the Russian press are often accompanied by complaints that industry is unwilling to employ new ideas or carry out the projects proposed.

The level of development of Russian engineering is considerably lower than Soviet propaganda and the official production figures appear to show, but it is still the engineering of a very large and rapidly expanding industry, and a better knowledge of its activities could be of great advantage even to engineers of the most advanced industrial country. Owing to its specialised and instructive character, the material published by Soviet journals would not appeal to the average reader of Western technical periodicals, and this is one of the main reasons why we know so little about Russian engineering; but it is undoubtedly of great value when put at the disposal of our specialists.

PEEPHOLES IN THE IRON CURTAIN

The Russians, for their part, keep a very watchful eye on developments in the field of engineering abroad, though until recently the official Russian attitude was that everything in the Soviet Union, including the living standard, was indisputably better than in the capitalist world. This applied also to the technical Press and no information on engineering activities in foreign countries ever appeared on the pages of Russian periodicals. Even in articles on general development in certain fields, the foreign contribution was usually described without reference to its origin, thus leaving the reader with the impression that the progress was due exclusively to the work of Russian technicians and scientists. Information on progress abroad is provided for those who need it in their work by a few special publications of limited circulation such as *Stankostroenie Zagranitse* (Machine Tool Engineering Abroad) and by a very extensive and well organised information service. In this service, abstracts and translations are prepared from articles published in over 6,000 scientific and technical journals and made available to the public in special periodical publications (Abstract Journals). The literature references in Russian scientific papers show that frequent use is being made of this service.

In a speech last year Mr. Khrushchev admitted that some foreign machines were better than the corresponding products of Russian industry. This meant a lifting of the ban on information about foreign engineering in the general technical Press. In the view of the Soviet Government, this is an important concession and is one of the measures taken after Stalin's death and intended to increase the real value of Russian industrial production, without sacrificing the basic principle of the economic system.

The obstacles to the exchange of information in the opposite direction are of a different nature: among these are language difficulties and the fact that not all Russian publications may be sent abroad. But many Russian periodicals are available outside Russia, and in some countries their translation and the distribution of translations is centralised, in order to overcome language difficulties, as it is in this country by the Department of Scientific and Industrial Research, the Science Museum library and other organisations. Indeed, it is possible that the flexible and enterprising industry of the Western world gains more from many Russian publications than does the somewhat harrassed industry in the country of their origin.

IMPROVED CARBIDES FOR MACHINING STEEL

It is many years since Wickman Limited, Bannerlane, Tile Hill, Coventry, varied the grades, classifications or structure of their carbide hard metals which are used in the form of tips for steel-cutting tools, but, after extensive tests, they have decided to introduce an entirely new series of grades, supplanting the present grades for certain applications. Two new grades, known as "XL2" and "XL3," are being introduced immediately and these will be followed by a further three grades which the firm plan to make available in May. These first two grades supersede the existing Wimet grades "XX", "XX7" and "X8".

A long period of examinations and tests began with an industrial survey in the United Kingdom in 1953, when technical opinions were sought from a number of individuals and organisations representing as far as possible all sections of the metal-working industries. In this survey criticisms of the performance of the available grades of carbide for steel cutting were openly invited. The resultant judgments, when summarised, clearly showed that the wider range of steels in use, together with the continued development in machine-tool design, created new conditions which could be met more effectively by a range of grades having extended wear and shock resisting properties. These could be achieved by an increased measure of toughness. In addition to the improved performance of grades for general finishing and roughing operations, additional toughness also offered other advantages in that the incidence of cracking during brazing and grinding would be reduced and there would also be less risk of edge snipping and cracking during service.

As a direct result of this survey and with full appreciation of the merits of the existing Wimet grades "XX," "XX7," "X8" and "S58," a programme of development and tests was begun and has continued during the past three years. One of the major problems which had to be solved was the establishment of a method of measuring toughness, since it had become increasingly clear that transverse rupture strength is of little significance in relation to the performance of cutting tools in practice. While no measure of permanent deformation occurs in a tensile or transverse rupture test, it is possible to deform carbide locally to a considerable extent before cracking occurs. For example, indentation can be made in the toughest carbide grades with a Vickers pyramid diamond without any visible cracking, but on closer examination, very small cracks are observed at the corners of the impression.

An attempt to use this method of observing cracking at the corners of the diamond impressions, as a measure of toughness, was made, but was not successful because of inconsistent readings, probably accounted for by the high concentration of stress at the corners of the impression. As a result, an entirely new approach was made using a spherical indenter applied to a flat polished surface at increasing loads, until a point is reached when cracking occurs at the periphery of the indentation. Measurement can be made by optical interferometry, which provides a relationship between the load and the depth of impression, up to the point at which the carbide begins to crack. A description of this method is given below. A carbide hemisphere has proved to be the most suitable type of indenter, and although it is flattened to some extent during the test, it is possible to classify carbide grades in terms of toughness according to the maximum depth of impression which can be made without cracking.

Figs. 1 and 2 show the optical interference patterns of indentations of maximum size which can be made in two different carbides of varying toughness. The number of interference rings is a direct measure of the depth of the impression (Fig. 1 shows 9 and Fig. 2 shows 23) and the number of rings can, therefore, be used as a measure of the toughness of the carbide. It is understood, of course, that the number is constant for reference purposes, only if the radius and hardness are also held constant. Both the grades illustrated have a transverse rupture strength of 103 tons per sq. in., but the one with the toughness reading of 9 (Fig. 1) is a grade which is known to be more susceptible to chipping in application than the one with the toughness reading of 23 (Fig. 2).

Having established a method of measuring toughness, several distinct approaches were then made to the problem of providing the desired physical properties. These included the modification of basic materials, carefully manipulated changes in chemical composition, and the employment of elements additional to those normally used in the manufacture of Wimet. This was followed by a series of laboratory tests to determine the best combination, and, by a process of elimination resulting from machining tests in the laboratory, a number of grades were selected to provide a later choice based on field tests under more rigorous production conditions. These field tests were carried out on an extensive scale, taking as a basis the widest applications of different operational conditions and materials it was possible to find. The tests, moreover, were conducted in direct comparison with the performance achieved by existing grades.

Care was taken to provide identical tool geometry to avoid the introduction of undesirable variables, and also to subject the test tools to identical conditions and amount of work produced per tool. From the large number of tests carried out, typical results concerning the cutting edges of tools used in three different machine-shop applications are given in Fig. 3 to 6. These illustrations show the improvement resulting from the increased toughness, namely, wear is more even and there is less chipping of the cutting edges, and less cracking due to thermal and mechanical stresses in the new grades.

Figs. 3 and 4 indicate the relative performance of the best of the experimental grades, compared with Wimet grade "X8," when applied to the machining of automobile crown wheels in En 352 L material on a Maximinor machine, carried out at a speed of 200 ft. per minute, and a feed of 0·004 in. per rev. It will be seen that in the case of the "X8" tool (Fig. 3) a greater amount of edge breakdown has taken place than in the case of the "XL3" tool (Fig. 4). Similarly, the flank wear was greater in the case of "X8"; in this particular case edge breakdown contributed to extensive wear.

Finally, Figs. 5 and 6 illustrate the performance

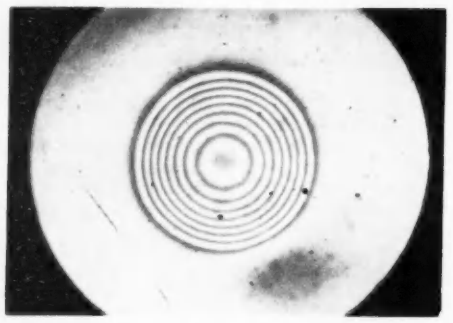

Fig. 1 Optical interference pattern of an indentation on a carbide grade of known chipping tendences.

Fig. 2 Optical interference pattern of an impression on a carbide grade possessing a higher degree of toughness than that shown in Fig. 1.

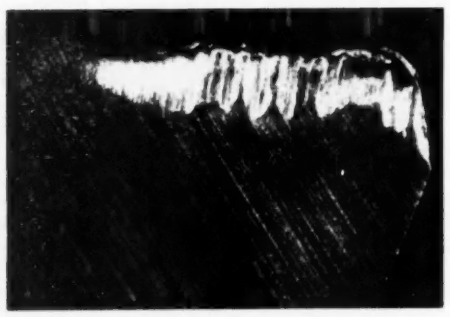

Fig. 3 Edge breakdown on an "X8" tipped tool after machining.

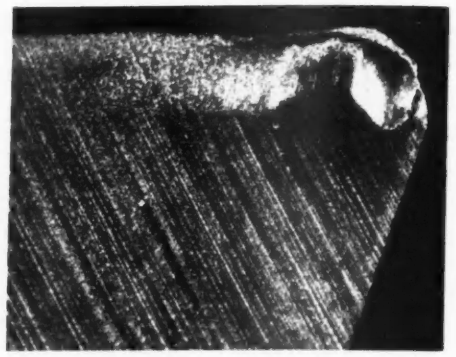

Fig. 4 Minimum wear on top surface of an "XL3" tipped tool.

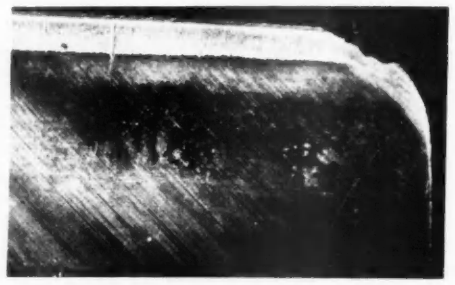

Fig. 5 High rate of wear, chipping and cracks due to thermal stress on top surface of an "X8" tool tip, after rough-turning operation.

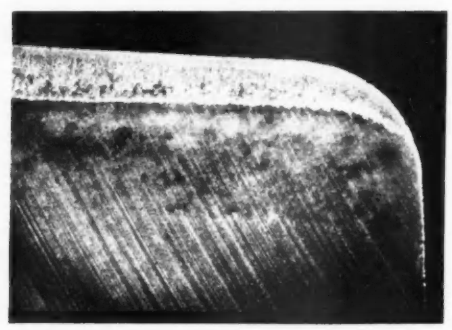

Fig. 6 Even wear and no cracking on top surface of an "XL3" tool tip after rough-turning.

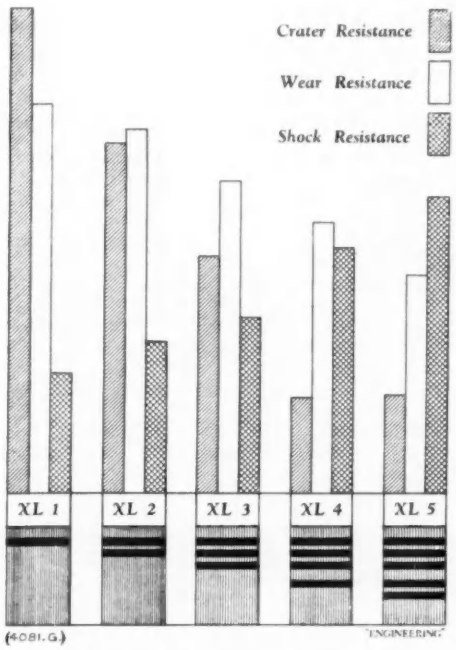

Fig. 7 Diagrammatic representation of the properties of the new Wimet carbide steel-cutting grades.

of the best experimental grade against Wimet "X8" when rough-turning sockets in En 18 material on a Ward No. 7 machine, carried out at a speed of 500 ft. per minute and a feed of 0·0075 in. per rev., with a $\frac{1}{16}$ in. depth of cut. In this case cracks have developed in the "X8" tool due to thermal stress, and chipping of the cutting edge has occurred, whereas the "XL3" tool shows only even wear and no cracking. Excessive flank wear on the nose of the "X8" tool was experienced.

Following upon these prolonged and searching tests, the final choice of grades has been made. The result, shown diagrammatically in Fig. 7, furnishes an entirely new range which will be known as the "XL" series, offering high wear-resistant properties at one end of the scale and considerably greater shock-resistant properties at the other. Each grade possesses its own degree of toughness and the gradation of properties will allow a choice of carbide to meet the wider demands now placed by industry on the hard-metal manufacturer.

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SUPPRESSION OF DANGEROUS SPRAY IN CHROMIUM PLATING

After exhaustive tests the efficiency of a surface-active fluorinated hydro-carbon agent called Zero-Mist in suppressing spray in chromium electroplating operations has been established, and the product has now been approved officially by the Factory Department of the Ministry of Labour and National Service as suitable for replacing the fans which were previously obligatory to protect the health of employees in the plating shop.

The product is available from the Electro-Chemical Engineering Company, Limited, Woking, Surrey, and it is stated that in tests which have been carried out recently it has been certified that in several cases when 3 cub. m. of air were taken from above a chromium-plating bath, the analyses have shown that less than 0·005 mg. of total chromium, expressed as chromium trioxide, was present in the atmosphere. The new product is claimed to possess "extreme stability" and it is emphasised that as it is lost from chromium plating solutions solely as the result of "drag-out," the rate of consumption is remarkably low once the initial addition of the required weight of tablets has been made. It appears, therefore, that operators of chromium-plating processes should be able to make important savings by adopting Zero-Mist.

In general, an exhaust ventilation system, such as has been obligatory previously to remove the mist or spray as it formed, also carries out a great quantity of air which has to be heated. For example, to carry away the mist formed in a 2,000 gallon tank installation, an exhaust rate of as much as 10,000 cub. ft. per minute may be required with consequent heavy cost, both in capital installation and in the power consumption of the electric motors. Furthermore, even with the most efficient ventilating systems it is not always possible completely to obviate mist formation, particularly with wide tanks and where there are strong draughts. There has also always been a persistent corrosion problem in the ducts and ventilation system which become coated with condensed corrosive salts. Furthermore, since the loss of chromic acid through mist and spray is appreciable this gives rise to considerable additional expense in addition to being a hazard to the health of the employees.

CONTROL OF QUALITY INSPECTORS

Quality control in industry usually implies statistical quality control (indeed, the terms are often taken as being synonymous). Nevertheless, it is interesting to note that statistical quality control is conspicuous by its absence in many firms where quality is a major consideration. The problems of quality that arise are tackled empirically by management along with all the other problems, or they are viewed from a purely technical angle, and those defects which cannot be remedied technically are accepted as inherent liabilities of the process. The fact that so many firms prefer to go their own way aroused the interest of Dr. R. M. Belbin and led him to study the subject with some care. The results he obtained are most interesting and are embodied in "New Fields for Quality Control," a paper presented at a recent meeting of the British Institute of Management and the Institute of Industrial Administration. One of the more significant items is the introduction of the "control sample technique." Dr. Belbin holds that quality control rested ultimately on the efficiency of the inspection system. There was of course at present no objective method whereby it can be told whether the examiner was inspecting adequately or not work of unknown quality. The new technique described represents an attempt to develop such a method. If, in normal batches of work, certain types of defect and measured performance were placed at random, against this known sample subsequent to viewing, it was possible to develop an objective means of assessing the efficiency of inspection.

The main difficulty was that of identifying the defective test items without making them conspicuous to the viewers. There were various techniques for doing this but one of the most versatile was the use of an invisible fluorescent dye to stain the test items. Once a defective test sample had been obtained it could often be used repeatedly. The method was simple and far less time consuming, once the initial work had been done, than reinspection. For example, a tray of 50 valves (with micas stained with eight-hydroxyquinoline), requiring about half an hour of work in inspection or reinspection and containing a few test items, could be checked in a few seconds under the ultra violet lamp. In the case of ampoules, hours of work could be checked in a very short time, for test items lying at the bottom of capacious trays, containing several hundred ampoules, fluoresced so strongly that they could be detected without difficulty.

The sample of defects used for test purposes did not need necessarily to be a cross-section of the faults found in normal work in order to give an index of individual efficiency on normal work. Indeed, management might require to bias the control sample in the direction of those faults about which management was most concerned. This technique, developed by Dr. Belbin, is termed "the control sample technique." This term seems well fitting for the sample acts as a control against which performance on the unknown batch may be assessed. He pointed out that if the number of defective items rejected by the inspector on the main batch and the efficiency of the viewer on the control sample were known, the actual number of defects in the main batch would be known fairly accurately even if as few as 15 per cent. of these were picked out by the inspector. For example, if inspector X is 65 per cent. efficient on the control (fluorescent) sample her efficiency could be assessed in rejecting faults on the main batch as being 50 per cent. Thus, if she had put out 100 rejects from a batch of 2,000 we could estimate that the remaining 1,900 ampoules contain a further 100 rejects which had escaped detection. Once inspectors were informed that their performance was due to be measured there was usually a marked improvement in efficiency. This improvement could be maintained because it was possible to feed information back to inspectors on the type and number of faults they were missing. By this means individual propensities to miss certain types of fault were quickly corrected. Finally it had proved possible to stabilise efficiency in viewing at a high level by using the information derived from use of this technique for purposes of incentive payment.

The actual technique whereby the sample might be reclaimed could vary a good deal. Apart from the use of fluorescence, radioactive isotopes and automatic counting (for example, the vacuomatic counter in the printing and paper trades) were also possible. It was important to find the most convenient technique. The method should be used as a means of analysing why faults were missed. It had been found, for example, that certain faults tended to pass because the viewing conditions or the handling technique were particularly ill-suited to the detection of a given defect. Sometimes the examiner had some misconception about what she should reject. Dr. Belbin emphasised that it was necessary to endeavour to stabilise the performance of examiners by making full use of the technique for "feed-back" purposes and for purposes of payment based on efficiency. Other parts of his paper dealt with the criteria by which articles were rejected. This point is dealt with in "Marketing," page 119, of this issue.

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STEELWORKS PLANT

In the last week of 1956 a new turbo-blower and a new open-hearth furnace were brought into service in the works of the Appleby-Frodingham Steel Company, Scunthorpe, a branch of the United Steel Companies Limited, Sheffield.

The turbo-blower, which is twice the size of the four existing units, is operated by a 20,000 h.p. steam turbine and is capable of delivering 150,000 cub. ft. of air per minute to the blast furnaces at a pressure of 35 lb. per sq. in. On account of the additional blowing capacity now available, it will be possible to obtain a higher output of pig iron from the company's four blast furnaces.

The new 300-350 ton tilting open-hearth furnace received its first charge on December 27 and was tapped for the first time on the following day. It is the third unit in the company's Frodingham melting shop, two earlier furnaces having been laid down in 1947. The new furnace is designed primarily for firing by cold coke-oven gas and pitch creosote, but mixed blast-furnace and coke-oven gas can be used after minor modifications. The annual output of the new furnace will be about 120,000 tons of steel.

Book Reviews

SHORT CUTS TO NEW SKILLS

Training Factory Workers. Prepared by the National Institute of Industrial Psychology. *Staples Press, Limited, Mandeville-place, London, W.1.* (12*s.* 6*d.*)

Some two years ago, the European Productivity Agency, which forms part of the Organisation for European Economic Co-operation, initiated Project 179 to determine what facilities and programmes were being used for the "in-plant" training of semi-skilled and unskilled workers in manufacturing industries in Europe. Seven countries agreed to participate and the National Institute of Industrial Psychology was not only nominated to undertake the United Kingdom survey, but was also elected to act as the co-ordinating institute for the whole project.

The present volume reports on the survey in this country, and deals with those jobs which take less than three years to learn. The period chosen means, of course, that apprenticeships were excluded from the investigation. During 1955, over two hundred establishments were visited in order to study the operation of "systematic" training. Inevitably, these establishments were not representative of industry as a whole, since non-manufacturing industries, such as mining and transport, were excluded, and some manufacturing industries had no examples to show. Nevertheless, the establishments selected were fully representative of the practices adopted by firms which devote some attention to the training of operatives. The textile, clothing and electrical industries, collectively, provided most of the examples.

After outlining the scope of the survey, and before presenting its results, background material is provided in two chapters devoted to educational and industrial organisation, and to the history of industrial training in the United Kingdom. Subsequent chapters deal with the establishments visited, the organisation of the training, the instructional practice, the results achieved, and the reasons for starting training schemes. A list of the jobs covered and selected examples of training practice are given in the two appendices. Although 200 firms constitute only a minute fraction of British industry, the quantity of material collected has been very considerable. This material has been well handled, and is clearly presented with the aid of numerous tables. Although only a very small proportion of firms have any organised form of training more complex than "training within industry," the varieties of approach and practice encountered were very numerous, and the firms visited ranged from those with a handful of employees to those with many thousands.

As a survey this report is competent, painstaking, objective and cautious, and should satisfy the Agency which financed it. Little adverse comment can be made about any of the statements put forward, and (apart from the addition of an index) little constructive criticism can be levelled at the arrangement of the material. There is a useful final chapter which summarises the conclusions from the survey under two headings: the principles of systematic training schemes, and their organisation.

To the engineer in industry, however, the book may appear depressing, and this view has already been put forward by several engineers. "It is an excellent account of all the difficulties to be encountered in systematic training," said one, "but we already know plenty of those; what we want to know is how to overcome them." And on this aspect the volume gives little help—justifiably, perhaps, in view of its restricted terms of reference as a survey. Again, the statistical revelation of the shortcomings of Britain's industrial training, while very salutary, appears in this book to hide the strenuous and intelligent efforts being made by numerous firms to overcome them: efforts attended with marked success.

To the factory manager, a thorough exposition of the factors involved in a situation may be less helpful than details of how someone else has successfully dealt with a similar problem. The manager who turns to this book seeking guidance on training his own factory workers will find little direct aid in his search. The experienced training officer, on the other hand, will be able, on a closer reading, to discover many valuable details of current procedure.

It is regrettable that no information is provided, or guidance given, to the inquiring reader about the most recent developments in operator training, either in the fields of research or application. In this country, there were at the time of the survey at least five research projects in universities and similar institutions on matters connected with industrial skills and training. These certainly deserved mention, and a chapter on them might be considered more relevant than one on the educational system. These and earlier researches are already contributing to improved practice in operator training in this country and overseas, and it will be misleading if the other European surveys contain reference to these developments, and infer that this country, which initiated them, has neglected them. Such references as are made to research are in very general terms, and the practical engineer who reads (on page 94) that "experiments in psychological laboratories have demonstrated the connection between the desire to learn and the rate of progress made" is unlikely to consider that such research is of value to him.

The position of operator training in British industry, though far from satisfactory, is much more healthy than the continental—or the English—reader of the book might be led to believe. An ever-increasing number of firms are taking a serious interest in operator training, and are grappling with the difficulties successfully. Enough has been done to convince enough of them that the better use of manpower achieved via training is a real aid to productivity and economically worth while. There is a small but growing body of training officers and instructors who now have the ability to analyse training requirements, to establish training courses and to use them effectively, and one industry at least, through its central body, is providing a basis for establishing sound operator training for its member firms.

On the research side, new knowledge of the nature of speed-skills is enabling training procedures to be more explicit and effective. Studies of human performance, which throw valuable light on training methods, are far from complete, but our knowledge of industrial skills and their acquisition is worth recording.

A survey of training procedures summarised in statistical tables is inevitably impersonal, whereas operator training is an intensely human affair concerned with men and women, both as individuals and in groups. The writers of this book cannot be blamed for the arid nature of their facts, but the reader should be warned that, to be successful, training of factory workers needs to be much more human than these tables of data suggest, and that good operator training comes as much from the heart as from the head.

ULTRA MECHANICS

Dynamics of Machinery. By JAMES B. HARTMAN. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (7.50 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (56*s.* 6*d.*)

The spate of a new type of book from America on mechanics of machines appears to be reaching full flood. Here is yet another, and it is a very good one, albeit an unusual one, and even more obviously than some it is really a substitute for lecture notes for the class to which the author lectures.

Professor Hartman sets out his object clearly at the beginning of his preface: "The design and control of modern high-speed machinery and the analysis of its performance require that the engineer have at his disposal techniques which cannot be adequately covered in the usual elementary courses in mechanics. The author has attempted to aid the reader in acquiring some of these techniques through the discussion of pertinent topics in dynamics. The text is intended for advanced undergraduate and graduate students in mechanical engineering." Bearing in mind the disparity between American and British standards, he has produced a book which should cause no serious difficulty to an undergraduate in his finals year. In addition, it should act as a useful corrective to those to whom it has never been clear that the statics of machinery is only a special case of its dynamics.

Despite the clarity with which he states his objective, the author in fact has failed to reach it. On the one hand, he provides some mathematical tools not usually met in books of this kind; and then tends to use them on problems more simply tackled by other methods. On the other hand, he treats many topics in such an elementary manner that their real interest is concealed. Nevertheless, any teacher must find the book stimulating. Whether he will recommend his pupils to do more than borrow it from the library, having noted that the price is £2 16*s.* 6*d.* is another question.

The first chapter, in which a lot of assumptions are reconsidered, is admirable, although one may doubt whether the introduction of vector notation for dealing with three-dimensional problems is really justified in a book of this kind; most men will have forgotten how to use it within a few months of graduating, and would be far better equipped for life by a thorough grasp of how to resolve their problems into two-dimensional ones. In discussing some principles of dynamics the author uses this approach to tackle a number of problems, including the gyroscope in its simplest form; he does not appear to realise that $m\frac{dv}{dt}$ is not the same as $\frac{d}{dt}(mv)$. A section on inertia forces is sound but unexciting, and it is a pity that a very promising introduction to the synthesis of machines occupies only the last paragraph. But why, oh why, must the cost of the book be increased by an entirely useless view of a Diesel engine? Apparently it is now the convention in American text-books that a few photographs of real machines must be introduced, irrespective of their relevance.

An account of mechanical vibrations is sound but thin, introducing Holzer's method, yet missing out systems with two degrees of freedom, involving damping and failing to use vector methods for the steady-state solution of vibration problems. The lack of appreciation of vectorial methods makes a treatment of balancing of machinery unnecessarily complicated; and while it is pleasant to find problems such as that of balancing flexible rotors mentioned, it is disconcerting only to find the most elementary special case of critical speeds discussed. A lot of space is wasted on half-tone illustrations once more.

In dealing with engine dynamics, Professor Hartman makes an unexpected incursion into the application of analytical tools to the design of an internal-combustion engine. In some respects it is a very good attack on the difficult question of how to do this, but some of the statements in it should not be taken without a pinch or two of salt.

A chapter on mechanical transients is in fact a sound introduction to the Laplace Transform method of solving differential equations and one looks in vain for mention of phase plane methods. In fact, it is really a mathematical prolegomena to the following chapter, in which

new ground is broken for a book of this type. Its subject is dynamics of automatic control systems, and it offers, for the first time so far as the reviewer is aware in books of this class, a sensible chapter in place of what is usually provided on governing. If it is wrong in its first paragraph—Clerk Maxwell in 1868 did the analysis on which Routh built—and if the treatment seems unnecessarily complicated, it is nevertheless a chapter to rejoice the cockles of one reviewer's heart.

Finally, the book contains a lot of good problems and their answers, and also some special projects to develop a professional approach to engineering problems. The bibliography, and the book in general, would have been much improved by the discovery that not only Americans have written on these topics.

AERIAL ANALYSIS

The Theory of Linear Antennas. By RONOLD W. P. KING. *Harvard University Press* and *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (160*s.*)

The first antenna was that devised by Hertz in 1887 for his experimental verification of the possibility of electro-magnetic wave propagation in free space, as predicted theoretically by Maxwell 23 years earlier. As a radiator the Hertzian dipole was not particularly efficient and, in Marconi's pioneer experiments, it was replaced by the second fundamental type of aerial—the grounded vertical wire. Far more complicated radiating and receiving antenna systems have been developed since then but even the simplest types have continued to present problems. Professor King, in his introduction, states that " publication of this volume was postponed for several years in order to achieve a hitherto unknown correlation between theory and experiment and, with it, to obtain a more complete understanding of the wire antenna driven from a transmission line." Generally speaking, mathematically rigorous solutions of antenna problems only become possible when a set of hypothetical boundary conditions is substituted in place of the actual boundary conditions; in other words when the situation dealt with is an artificially simplified version of the real situation, usually excluding features essential to the real situation. Of more immediate practical consequence are methods in which some rigour is sacrificed in order to incorporate a closer approximation to the actual boundary conditions. It is only by requiring that the assumed boundary conditions fit the actual conditions closely that account can be taken of essential differences characteristic of particular structures. Abundant evidence of the insight and experience needed to ensure that acceptable simplifying assumptions are made in the proper place is provided in the 900 double-column pages of this massive monograph.

The introductory section comprises a general survey of methods of solving antenna problems and a summary of the essentials of electromagnetic theory. In chapter II the circuit properties of a single antenna of very simple structure are investigated, with the assumption that the antenna and its associated network constitute a completely isolated transmitter. Various alternative methods of formulating the problem of a cylindrical antenna of sufficiently small cross-section to make a one dimensional analysis an acceptable approximation are discussed and used to derive the current and charge in the antenna, together with its theoretical impedance. Antennas having cross-sections large in comparison with the wave length, which necessitate a three-dimensional analysis, are not considered. The study is then extended to arrays of linear radiators.

In chapter IV, on the receiving antenna as a circuit element, the general analysis of two different arbitrarily oriented and arbitrarily spaced antennas is undertaken. The equations thus obtained are then specialised to the case of great separation in order to derive the essential properties of receiving and scattering antennas. The two succeeding chapters are devoted to a consideration of the electromagnetic field of centre-driven and multiple half-wave antennas, and of antenna arrays. As the general case of unlike antennas, or even identical antennas in an arbitrary orientation has not been solved, except when the antennas are in the radiation zone with respect to one another, much of the analysis is approximate, and the deductions from it are compared with data obtained by experiment. In order to determine the electromagnetic field that governs the response of a receiving antenna it is necessary to solve the problem of an antenna above a conducting earth with an associated magnetic field. This involves so many variables and parameters that a complete solution of the entire problem is extremely difficult. Attention is confined in chapter VII to the primary electromagnetic field of the ground wave, while the contribution of the sky wave reflected from the ionosphere is ignored. The concluding section is devoted to the impedance and radiation resistance of antennas over conducting planes. In the final chapter, in which the antenna is treated as a boundary value problem, the primary emphasis is on the mathematical approach, and a critical examination of the various approximations relating to hemispheroidal, conical and cylindrical antennas is undertaken.

The large number of diagrams and the numerous tables form a notable feature of the book. Within the limitations imposed, the whole subject is covered in a remarkably systematic and comprehensive manner. Much of the material included is new, being based on research work carried out in the Cruft Laboratory at Harvard University by the author and his colleagues. The theoretical analysis—rigorous whenever possible—its application to real rather than to idealised structures, and its careful correlation with the results of experimental investigation, combine to make Professor King's monumental work an indispensable source of reference to the radio and electronic engineer.

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NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Electronic Analog Computers (D.C. Analog Computers). By GRANINO A. KORN and THERESA M. KORN. Second edition. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (7.50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (56*s.* 6*d.*)

The author's aim is to acquaint research and development workers with tried methods for the application of direct-current analogue computers as computing aids and simulators, and with the possibilities and limitations of such equipment; and to present a comprehensive account of up-to-date design information on computer components and systems. A knowledge of advanced mathematics is not called for. In this second edition, additional information is given on late chopper and commutator-stabilised direct-current amplifiers; photo-electric chopper circuits; frequency-modulation/amplitude-modulation multipliers and time-division multipliers; design of precision electronic switches; modern simulation techniques applicable to non-linear servos and process control systems; use of diode function generators; generation of functions of several variables; computers with automatic programming features; and problem check circuits.

The Art and Science of Protective Relaying. By C. RUSSELL MASON. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (12 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (96*s.*)

The book is based on notes used in the Power Systems Engineering Course given by the General Electric Company of America. The author deals first with the purpose of protective relay systems, and then goes on to consider the fundamental operating principles. This is followed by descriptions of relays for specific purposes, and then by chapters dealing with protection systems for particular parts of electrical systems. These include generator, transformer and bus zone protection. Each chapter concludes with a bibliography and a series of problems.

Properties of Combustion Gases: System C_nH_{2n}—Air. Vol. I: Thermodynamic Properties; Vol. II: Chemical Composition of Equilibrium Mixtures. Prepared by the Aircraft Gas Turbine Development Department of the General Electric Company, Cincinnati, Ohio. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (75 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (562*s.* 6*d.*)

After a brief introductory text which describes the use of the tables, the two volumes are composed almost entirely of tables of all the thermodynamic data likely to be required by the designer of the air-breathing combustion engine, and particularly by those engaged in the design of engines for the jet propulsion of aircraft or in research on combustion reactions. The data are concerned with combustion products of any hydrocarbon fuel of the general formula C_nH_{2n}. Volume I lists in English units values of enthalpy, entropy, mean molecular weight, density, sonic velocity, heat capacity and non-ideality coefficients. The temperature range is 600 deg. to 5,000 deg. R., the pressure from 0·01 to 30 atm., and the fuel/air equivalence ratio from 0·25 to 4·0. Volume II lists the equilibrium chemical composition of combustion gases for temperatures above 2,500 deg. R. The following species are considered: A, C_s (graphite), CO, CO_2, H_2O, O_2, N_2, H, O, N, NO, OH, CH_4, NH_3. In addition, there are tables of values for the enthalpy, Gibbs free energy, entropy, and heat capacity functions of the above pure species in the range 600 to 5,000 deg. R. In all, the two volumes comprise what is probably the most complete tabulation of these classes of data.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Electric Relay. ELECTRICAL REMOTE CONTROL CO. LTD., Elremco Works, East Industrial Estate, Harlow New Town, Essex. Type MIR, for operation on alternating or direct current, has direct mounted contact blades on insulating panels as a substitute for contact piles. Loads of up to 6 amps. at 230 volts a.c. can be handled. Type MIR/P has a larger insulating panel with stationary contacts. Leaflet.

Trace Record Analyser. BENSON-LEHNER CORP., 11930 Olympic Boulevard, California, U.S.A. The Oscar Model J is for rapid reduction of trace records appearing on film or paper. The machine automatically applies linear and non-linear calibration factors to amplitude measurements, and zero shift may be compensated for. Output range is from 000 to ± 999. Illustrated leaflet.

Settling Tanks. AMES CROSTA MILLS & CO. LTD., Moss Iron Works, Heywood, Lancashire. Simplex circular settling tanks for preliminary and final settlement of sewage, including activated sludge, and for settlement of most trade effluents. Six different types in capacities from 2,500 to 3,000,000 gallons. Illustrated descriptive booklet.

Flow Metering Valve. BIRFIELD INDUSTRIES LTD., Stratford House, Stratford-place, London, W.1. Solenoid-operated water-flow control valve for flow rates from ¾ gallon to 5 gallons per minute. Suitable also for air. Illustrated specification leaflet.

Air Surveys. HUNTING AERO SURVEYS LTD., 4 Albemarle-street, London, W.1. Applications of air survey—examples of large and small scale surveys, topographical mapping and models, geological, forestry and agricultural surveys. Collection of leaflets bound in folder.

Self-Tapping Inserts. TAPPEX THREAD INSERTS LTD. 46 High-street, Warwick. Self-tapping self-locking bushes, internally and externally threaded, for metals and plastics, in cadmium-plated steel or brass. Illustrated leaflet.

Industrial Locomotives. DAVEY, PAXMAN & CO. LTD., Standard Ironworks, Colchester. Examples of steelworks locomotives fitted with Diesel engines. Publication No. 1511.

BEAMS WITH FULL END FIXITY

AXIAL FORCES MAY INCREASE LOAD CAPACITY MANY TIMES

By R. M. Haythornthwaite, PH.D.*

The plastic analysis of a fully encastred beam at finite deflection indicates that induced longitudinal forces will increase the load-carrying capacity substantially after only moderate deformation. Tests of three massively restrained steel beams of rectangular cross-section show that a simple plastic rigid theory represents post-yield behaviour very well over the common range of span-depth ratios.

For a wide range of framed structures, including simple beams and portal frames, tests[1] have established that the load-carrying capacity may be estimated reasonably well by determining the limit load of a model similar in form to the original structure, but composed of an ideally plastic material. The effect of axial forces on the bending strength of the members is usually neglected. A factor in the success of this approach is the comparative insensitivity of these structures to deflection either before or after yield. Not all structures possess this convenient attribute. For plates, membrane stresses may be important even at moderate deflection[2], and the limit load of an ideally plastic model is then a poor measure of the carrying capacity at finite deflection. In general, specific experimental evidence is required before the limit load can be interpreted adequately for a particular class of structure.

Reasons why axial forces may be neglected in certain beams and frames have been advanced by Onat and Prager.[3] They point out that an axial force tends to move the effective centre of rotation of a plastic hinge away from the centroid of the cross-section, but a substantial shift is required to affect appreciably the carrying capacity. The movement is small for the forces commonly present, so neglecting the axial forces does not introduce a large error. A well-known exception is any arch in which the thrust line remains close to the line of centroids: the effective centres of rotation of the plastic hinges will be remote from the centroids, so axial forces cannot be neglected. A less obvious exception is the fully encastred beam. Axial forces are initially zero at the yield load but build up rapidly because the nature of the collapse mechanism transports the effective centres of rotation away from the centroids. The resulting increase in carrying capacity is substantial and in many cases is available at moderate deflection.

Before proceeding with the analysis of the fixed beam, certain well-known results[4] for the plastic action of a section subject to combined bending and tension will be reviewed. For simplicity we shall consider only beams of rectangular cross-section, with a width B and depth H, as shown in Fig. 1, though other symmetrical cross-sections may be dealt with in the same manner.[4] If the material is perfectly plastic, after the yield stress in simple tension, σ_0, is reached, either an axial force $T_0 = \pm \sigma_0 B H$ or a bending moment $M_0 = \pm \sigma_0 \frac{B H^2}{4}$ acting on a cross-section will induce full plasticity of that section.

* Assistant Professor, Division of Engineering, Brown University, Providence, Rhode Island.

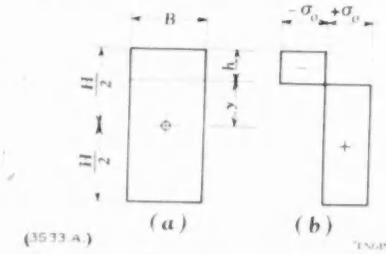

Fig. 1 Stress distribution in a rectangular beam developing full plasticity.

To examine the effect of combinations of axial force T and bending moment M, consider the case in which the neutral fibres are at a height y above the centroid, Fig. 1(*a*), all fibres above being stressed to $-\sigma_0$ and all below to $+\sigma_0$, as indicated in Fig. 1(*b*). For equilibrium $T = B(H - 2h)\sigma_0$ and $M = B(H-h)h\sigma_0$. Eliminating h, it is found that $t^2 + m = 1$, where $t = \frac{T}{T_0}$ and $m = \frac{M}{M_0}$. Similarly, if the bending moment is negative, $t^2 - m = 1$ and the two results can be combined as

$$t^2 + |m| = 1 \quad . \quad . \quad (1)$$

which defines the yield line in the m,t-plane, shown in Fig. 2.

The height y of the neutral fibres also specifies the ratio of the rate of rotation ψ' between adjacent cross-sections to the rate of extension e' of the centroidal fibres, the rates being taken with respect to any measure of the deformation. Thus $e' = y\psi' = \left(\frac{H}{2} - h\right)\psi' = \psi' \frac{tH}{2}$ for equilibrium.

In general

$$t = \frac{2}{H}\frac{e'}{|\psi'|} \quad . \quad . \quad (2)$$

As expected[5], comparison of equations (1) and (2) confirms that the vector $\left(e', \psi' \frac{H}{4}\right)$ is normal to the yield curve, Fig. 2. The yield curve is convex, so a specified ratio of e' to $\psi' \frac{H}{4}$ determines uniquely the axial force and moment present during the movement.

PLASTIC ANALYSIS

Consider a beam of span L fully encastred at both ends and subject to a load P, as shown in Fig. 3. As is well known, the incipient collapse mechanism at zero deflection requires the development of three plastic hinges at A, B and C respectively, indicated diagrammatically in Fig. 3(*b*), and by the dotted lines in Fig. 3(*a*). The yield load P_Y associated with the mechanism at zero deflection can be readily found by applying the principle of virtual work. Thus for a small deflection $\Delta\delta$, $P_Y \Delta\delta = 2 M_0 \Delta\psi_A + 2 M_0 \Delta\psi_B$ and since $\Delta\psi_A = \frac{\Delta\delta}{a}$, and $\Delta\psi_B = \frac{\Delta\delta}{b}$,

$$P_Y = \frac{2 M_0 L}{a b} \quad . \quad . \quad . \quad (3)$$

Now consider equilibrium of half the beam at a finite deflection δ, as shown in Fig. 3(*c*). For horizontal equilibrium the horizontal tensions T in the beam at A and at C must be equal. When the angles ψ are small, T will approximate to the tensions acting across the plastic hinges at A and at C. From Fig. 2, the bending moments at A and at C are then equal in value, and moment equilibrium of AC and CB requires that $P = (2 M + \delta T)\left(\frac{1}{a} + \frac{1}{b}\right)$; hence, using equation (3),

$$p = m + 2\frac{\delta}{H} t \quad . \quad . \quad (4)$$

where $p = \frac{P}{P_Y}$. The tension t is found by the flow rule, equation (2). Assuming a truly vertical movement of C, then $e'_A = \frac{\delta}{2a}$, $\psi'_A = \frac{1}{a}$ and $e'_B = \frac{\delta}{2b}$, $\psi'_B = \frac{1}{b}$, resulting in equal values of t. (Rates have been taken with respect to δ). Thus vertical movement does occur, and $t = \frac{\delta}{H}$. Substituting this value in equation (4) after using equation (1),

$$p = \begin{cases} 1 + \left(\frac{\delta}{H}\right)^2 & \text{when } \frac{\delta}{H} \leqq 1 \\ 2\frac{\delta}{H} & \text{when } \frac{\delta}{H} \geqq 1 \end{cases} \quad . \quad (5)$$

The yield condition is reached only at the assumed plastic-hinge positions A, B and C, Fig. 3, so equations (5) are an exact solution within the limitation $\delta \ll a, b$.

It is of interest to note that the effective hinge centre at A is $\frac{e'_A}{\psi'_A} = \frac{\delta}{2}$ below the centroid of the cross-section, as indicated in Fig. 3 (*d*). Simi-

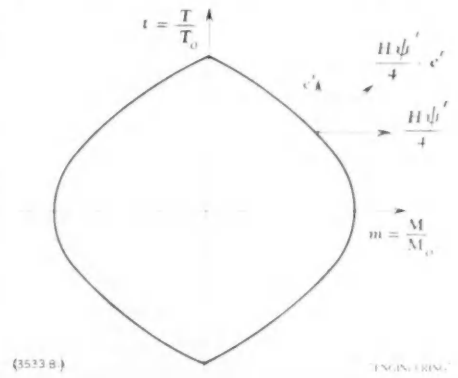

Fig. 2 Relationship showing proportions of the maximum tension force and the maximum bending moment required jointly to induce the yield stress. If an extension rate axis e' and a factored rotation rate axis $\frac{H\psi'}{4}$ are superimposed as shown, the vector with these components is always at right-angles to the yield curve.

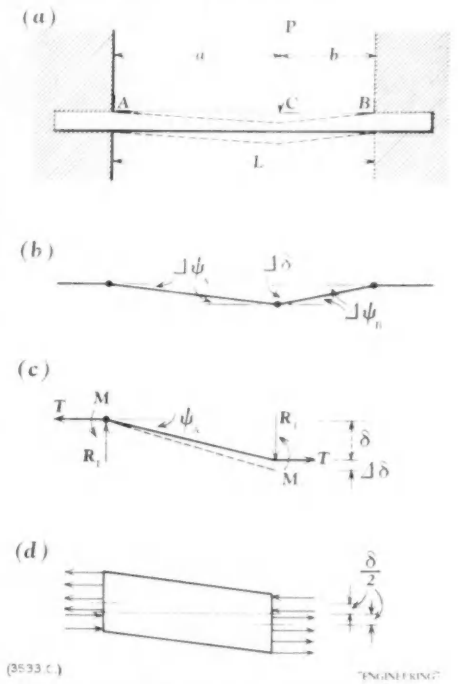

Fig. 3 The analysis of the stress condition in a rigidly encastred beam, when plasticity has developed. Fig. (d) illustrates the stress distribution at finite deflection. The neutral axis drops the same distance at the supports as it shifts at the applied load.

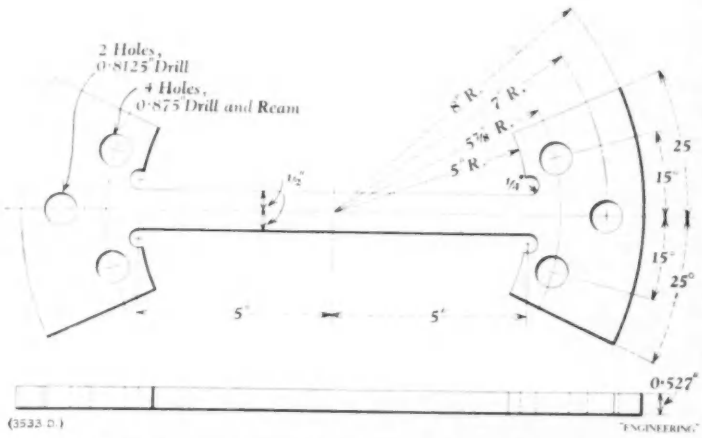

Fig. 4 Detailed dimensions of test beam B, showing the much enlarged ends for ensuring the maximum fixity at the supports.

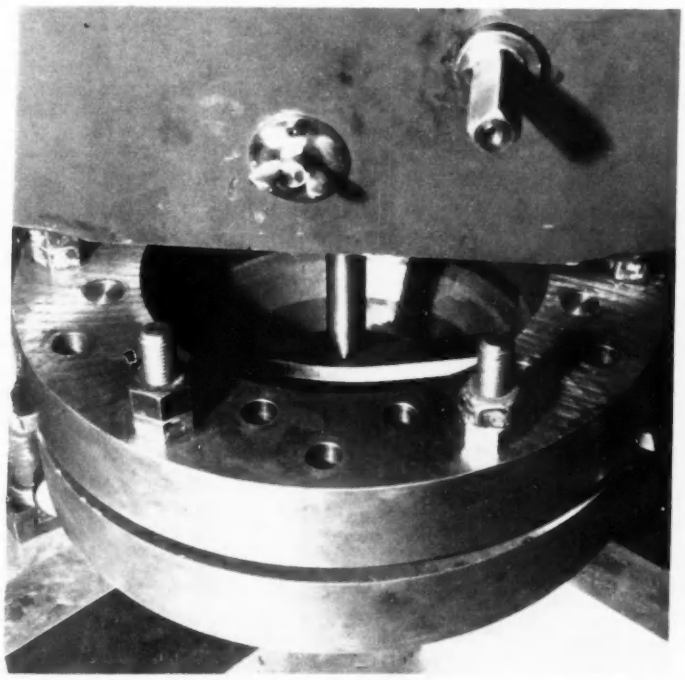

Fig. 5 Beam B mounted in the steel rings used to obtain full end fixity in respect of both bending and direct tension.

larly at C the plastic hinge centre is $\frac{\delta}{2}$ above the centroid of that cross-section. Thus as deformation occurs, the effective hinge centres move rapidly away from the centroids and the axial forces become significant at deflections of the order of half the depth of the beam. An alternative approach to the problem would be to assume a direction of movement of the rigid parts AC and CB. The effective hinge centre at A is at the instantaneous centre of the rigid bar AC relative to ground and that at C is at the instantaneous centre of AC relative to the punch. Only one direction is associated with forces that satisfy horizontal equilibrium, namely vertical movement of the midpoints of AC and CB. The eccentricities of the plastic-hinge centres are then each $\frac{\delta}{2}$, as found by the first analysis.

The above results are also applicable to the case of cyclindrical bending in plates.

BEHAVIOUR OF ENCASTRED BEAMS

Three steel beams have been tested in a first attempt to explore the reliability of the above approach for steel structures. The theory is most likely to be of practical use for the range of span-depth ratios in which membrane action is relatively unimportant in the elastic range and yet substantial deflection can be expected before strain hardening limits the maximum curvature. Beams with span-depth ratios of approximately 10, 20 and 40 were chosen with these points in mind. The beams, designated A, B and C respectively, were cut from hot-rolled plate nominally 1 in., ½ in. and ¼ in. thick. Details of a typical test piece are shown in Fig. 4.

The beams were mounted in turn between heavy steel rings as indicated in the sketch on Fig. 6. To ensure a high degree of fixity in tension as well as in bending, two steel pins each 0·001 in. oversize were driven through the beam and rings at each end and the rings were bolted together at six places. For the test, the assembly was mounted on steel blocks in a screw-driven testing machine and the load was applied to the beam at midspan through a hardened steel punch, ½ in. in diameter. Deflection of the beam at midspan was measured relative to the rings by a dial gauge reading to 0·001 in. In the plastic range deflection was induced at a uniform rate, each test taking about one hour to complete. Fig. 5 shows beam B under test.

The results for the three tests are plotted non-dimensionally in Fig. 6. The full line is a plot of equations (5) and represents the prediction of the theory based on ideal rigid-plastic material. The plots have been obtained by use of the dimensions and properties of the three beams as summarised in Table I. A large number of yield stress determinations was available for each of the plates from which the beams were cut[6]. The averages of these were used to compute M_0 and P_Y for each beam. In computing the yield load, the finite width of the punch—necessary to limit local damage—was allowed for by assuming the beams to be rigid over the central ¼ in. (half the width of the punch). To obtain extreme cases, the punch might be thought of either as acting as a knife edge or as causing the beam to be effectively rigid over the entire width of the punch. Either case would result in a change of 2½ per cent. in the collapse load; the theoretical curve may therefore be incorrect by ± 2½ per cent. due to this factor. This possible error is insignificant when compared with the gross effects observed.

TABLE I.—*Dimensions and Properties of Three Steel Beams.*

Beam designation		A	B	C
Breadth B, ..	*in.*	0·501	1·000	1·000
Depth H, ..	*in.*	1·015	0·527	0·244
Av. yield stress σ_0,*	lb. per sq. in. × 10^3	30·1 ± 0·4	33·7 ± 0·6	36·2 ± 0·6
Number of yield tests		17	21	16
$M_0 = \sigma_0 B \frac{H^2}{4}$,	*lb.-in.*	3,880	2,340	525
Span L, ..	*in.*	10·0	10·0	10·0
Effective span L'	*in.*	9·75	9·75	9·75
$\frac{L'}{H}$		9·63	18·5	40·0
Yield load $8\frac{M_0}{L'}$	*lb.*	3,180	1,920	430

* 95 per cent. confidence limits for the average.

To throw light on the role of strain hardening, an unstrained portion of each beam was tested in bending over free supports 5 in. apart, the load being applied at midspan by the ½ in. diameter punch used for the earlier tests. The results are plotted non-dimensionally in Fig. 7 in such a way that the slopes may be compared directly with those of Fig. 6. The strain-hardening conditions were not identical at a given deflection due to the presence of large axial tensions in one case and small ones in the other, but the continued rise of load in Fig. 7 probably gives some indication of the extent of strain hardening present in the encastred beam tests. If this is accepted, use of Fig. 7 to correct the curves in Fig. 6 brings each of the latter very close together in a zone just below the theoretical line for the rigid-plastic material. This suggests strongly that much of the observed rise above the theoretical curve may be attributed to strain hardening.

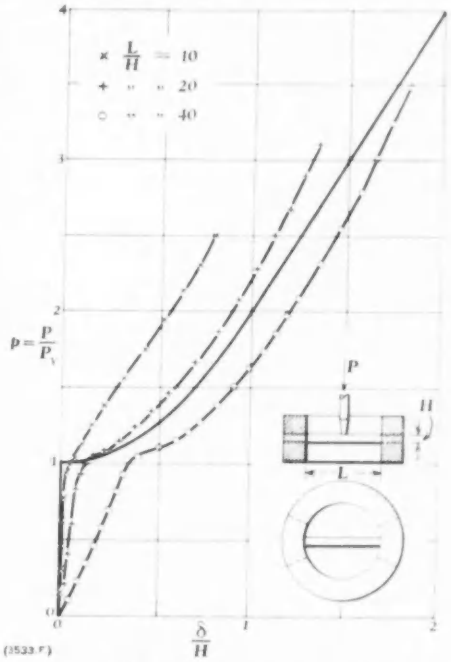

Fig. 6 Non-dimensional plots of results from tests on three steel beams, the diagram shows the test arrangement with a beam mounted between massive rings. The theoretical curve, based on an ideal rigid-plastic material and full end fixity is shown by the heavy line. Departure of the observations from this line is attributed partly to strain hardening (see Fig. 7). For a simply supported beam of span L, $\frac{P}{P_y} = \frac{1}{2}$ and the results show that the development of end fixity may increase the load capacity of the beam to as much as six or seven times this value.

CONCLUDING REMARKS

The simple plastic-rigid theory presented here would seem to give an excellent picture of post-yield behaviour for mild-steel beams having a span-depth ratio in the neighbourhood of 20. For deeper beams strain hardening is likely to have a progressively greater influence but it is, however, impossible to make a quantitative statement of general applicability because strain hardening varies so much, depending on the precise treatment the steel has received. If conservative estimates of deflection are required, some allowance for elastic deflection is necessary. A simple empirical rule would be to add the computed elastic deflection at the yield load

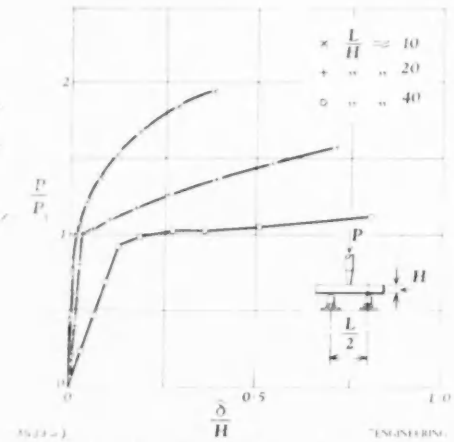

Fig. 7 Non-dimensional plot of the results with the beams freely supported, as shown in the diagram. The rise of the curves after yielding is a measure of the strain hardening induced in each beam and is nearly equal to the discrepancy between the plots and the expected curve in Fig. 6

to the estimate of deflection obtained by use of the rigid-plastic model. On the other hand, a full elastic-plastic analysis can be made whenever the extra work is justified.[7]

The study makes it clear that fully encastred beams possess a reserve of strength far in excess of the conventional limit load. A substantial part of this reserve is available at moderate deflections. Barring collapse of the beam due to other causes such as lateral instability,[8] this large reserve of strength would be realised under emergency conditions. The test results shown in Fig. 6 confirm that the fully-fixed beam may develop not twice but six or seven times the load-carrying capacity of the freely-supported beam. Thus for maximum safety it may be very worthwhile, especially under dynamic conditions,[9] to provide for the development of high longitudinal forces by suitable detailing of the end connections, and to design the rest of a structure so as to present maximum stiffness against longitudinal movement of the beam.

Acknowledgment.—The results presented in this article were obtained as part of the research programme of the Division of Engineering, Brown University, Providence, Rhode Island, U.S.A. The work was sponsored by the Office of Ordnance Research, U.S. Army, under Contract No. DA-19-020-ORD-3172 (Project No. TB2-0001(1086)).

The author is grateful to Professor Daniel C. Drucker for encouragement and advice and to Mr. T. Evans for assistance in the laboratory.

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AUTOMATIC GEAR CHANGING

ELECTRO-PNEUMATIC SPEED-TORQUE CONTROL

It has long been the aim of most manufacturers of motor vehicles to reduce the amount of labour involved in driving and consequently the driver's fatigue. The fluid-flywheel with a pre-selective epicyclic gearbox was one of the earlier stages in this programme which much simplified gear changing. The provision of pneumatic operation further reduced the effort required. More recently, A.E.C. Limited introduced the Monocontrol system in which the fluid-flywheel is combined with an air-operated direct-acting epicyclic gearbox, the gear change of which is controlled by a gate switch mounted on the steering column, actuating the air valves electrically. The most recent advance has been demonstrated by A.C.V. Sales, Limited 50 Pagestreet, Westminster, London, S.W.1; it is the Automonocontrol, which is completely automatic in operation, the gear change depending on a combination of the road speed and the depression of the accelerator pedal. It has been developed by C.A.V. Limited, Warple-way, Acton, London, W.3.

In this system, signals derived from the road speed and the torque requirements, as determined by the depression of the accelerator pedal, are summated in a relay box which then selects the gear suitable for those conditions. This relieves the driver of control of the transmission and should contribute towards a reduction in fatigue and to greater road safety. The conditions under which gear changing will be effected can be adjusted to suit particular conditions of service, and a manual over-riding control can be provided if this is considered desirable. Prototype equipment has been in use on some buses, mainly on London Transport country services, and has proved satisfactory over several months. The control system has been designed for specific application to vehicles already incorporating a Wilson-type direct-acting pneumatic gearbox, but can also be adapted for use with an electro-hydraulic system of gear operation. For a fully automatic system of this type, the only manual operation required from the driver is the selection of foreward or reverse motion as desired.

The equipment is made up of five units, shown in Fig. 2. They are, first, the electro-pneumatic valve unit which, as can be seen from Fig. 1, is mounted on the rear of the gearbox and contains a set of five solenoid-operated pneumatic valves connected by short pipes to the brake-band operating cylinders. The valves are in a common gallery which is supplied with compressed air from the main reservoir. Second, the selector unit which is similar to that used with the Monocontrol system, having positions for four forward and one reverse gear but with the addition of a position for automatic operation. This is mounted on the steering column and is connected by a multi-core cable to the electro-pneumatic valve unit. Third, a speed-sensitive alternator which is a permanent-magnet machine, mounted on the rear of the gearbox and driven from the transmission shaft at a speed proportional to the vehicle speed. The output from this alternator is fed to the control unit and supplies the signal corresponding to the road speed. The electrical connections to it are made by a set spring-loaded contacts which enables the alternator to be removed without disconnecting any leads. The fourth of the items involved is the control unit: this includes three voltage-sensitive relays fed from the road-speed alternator. Each of these relays controls a multi-contact relay which energises one of the gear solenoid and, by interlocks, prevents the operation of any other gear solenoid. A second winding on each relay receives the signal for the engine-torque requirements as determined by the driver's depression of the accelerator pedal. Thus the summation of the two signals controls the operation of the relays. The control box can be fitted in any convenient position. The fifth unit is the accelerator switch, consisting of a series of three contacts which are made in sequence according to the depression of the accelerator pedal: Their points of making correspond to the one-third, two-thirds and fully depressed positions.

When running in a forward direction the control system automatically changes the gear at values depending on the vehicle speed and torque requirements; maximum torque is thus obtained from the engine in any gear if the accelerator pedal is fully depressed. The diagram in Fig. 3 shows the speeds at which the changes are effected in the three positions of the pedal. For normal driving the pedal is not fully depressed continuously, so that, in consequence, the change into a higher gear occurs at a lower speed than when the vehicle is being driven hard, thereby enabling fuel economy to be obtained and giving an overall reduction of wear and tear on the vehicle. Similarly, the speeds at which downward gear changes occur also depend on the accelerator position. As already noted, one of the features of the system is that the speeds at which the changes are made can be adjusted to suit different operating conditions (as, for instance, in very hilly or very flat districts); this is done by simply changing a resistance in the control box.

To avoid excessive gear changes when the vehicle is coasting to rest on a light throttle, top or third gear is held until the road speed reaches between 2 and 3 m.p.h., when a change is made directly to neutral. Should, however, the pedal be depressed before the vehicle stops, in order to

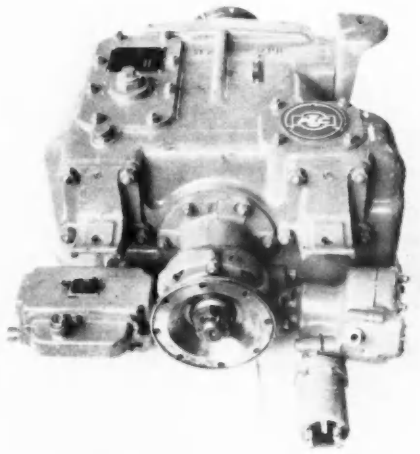

Fig. 1 Two of the units of the A.C.V. automatic gear-charging system, the electro-pneumatic gear selector and the road-speed alternator, are fitted to the transmission end of the gearbox, on the left and right respectively.

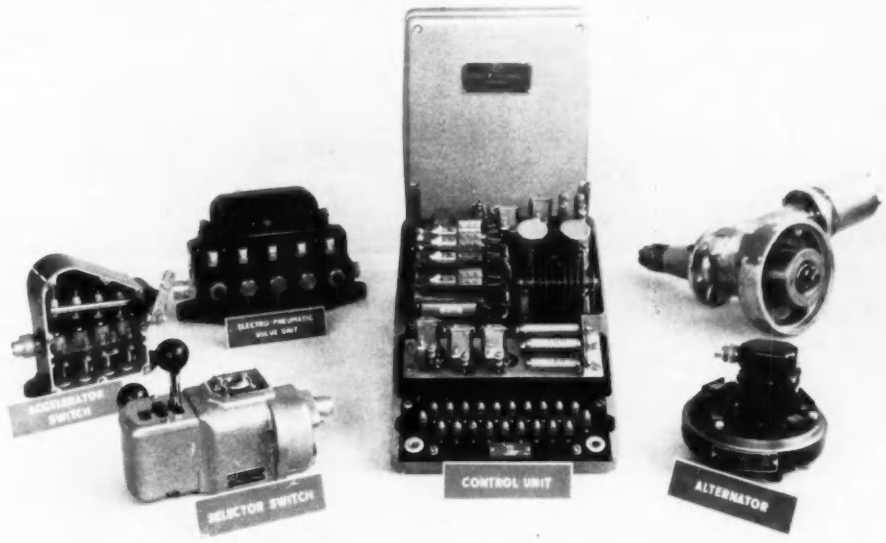

Fig. 2 The five units making up the A.C.V. gear-changing system are shown here, together with the drive for the alternator that supplies the signal corresponding to the road speed.

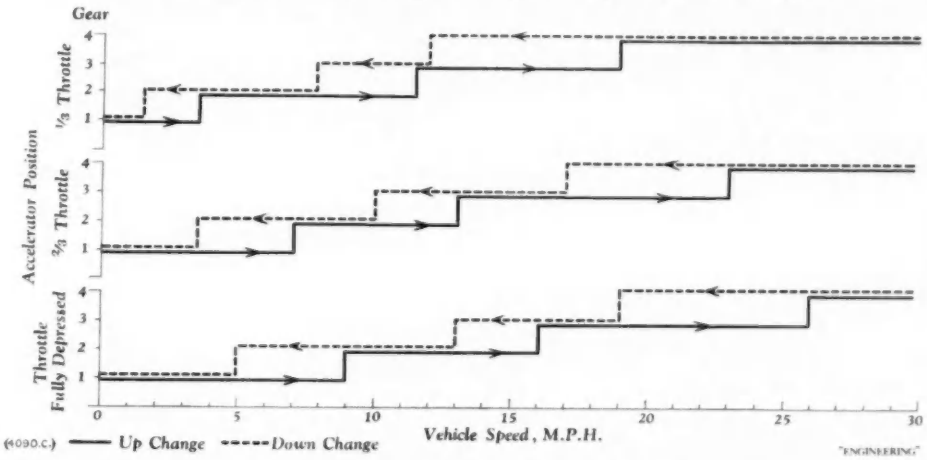

Fig. 3 The gear changes shown above were obtained on vehicle of gross weight 10 ton 4 cwt. when tested on level ground. The diagram indicates the interrelation of speed and accelerator position.

regain speed, the gear corresponding to the requirements would be selected directly. When the vehicle is at rest, neutral is automatically selected, the engine returning to idling speed; the slip in the fluid-flywheel which would then occur if the driver put in first gear is avoided, with consequent fuel economy. When the driver wishes to start from rest, depression of the accelerator pedal automatically re-selects the first gear by the action of a pair of contacts which also control the reversion to neutral when the engine is idling.

It is possible with this system to incorporate in the unit all or only some of the gears of the vehicle an example of when one gear may be conveniently excluded; is where the first gear is not normally employed and is kept for emergency use. In this case, first gear is selected on the manual control when required and is by-passed when using the automatic system, the vehicle pulling away from rest directly in second. The change up to third is then made at 15½ m.p.h. for all pedal positions. Manual selection is also required for use when the vehicle is going downhill and it is desirable to use the engine as a brake, for the automatic system would receive no signal which would cause it to change to a lower gear.

The makers emphasise that this system is a logical development of a method that has already been proved over long periods of service and add that existing Monocontrol systems can be adapted directly to Automonocontrol. It is also possible, of course, to replace other types of gearbox with the modified version without alterations to the engine or the transmission.

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DIESEL FUEL PUMP WITH PNEUMATIC GOVERNOR

A range of multi-cylinder camshaft pumps manufactured by Bryce Berger, Limited, Staines, Middlesex, is now available fitted with pneumatic governors. In the accompanying illustration can be seen a complete unit, as exhibited at the recent Commercial Motor Show and Public Works Exhibition. With the present trend of small Diesel engine design towards smaller and lighter engines running at higher speeds, its lightness and compact construction are particularly attractive.

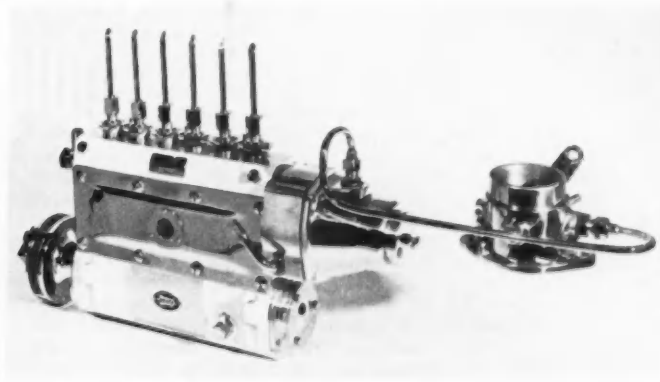
The Bryce A-size camshaft pump caters for the higher duties imposed by this trend, by employing roller bearings of the same size as used in the larger B-size range of pumps. This enables a stiff robust camshaft to be used which is better able to resist the dynamic deflections, and which, with the high load-carrying capacity of the bearings, contributes to a longer pump life.

The governor unit is capable of controlling the engine speed at any value between the maximum and idling speeds, which are predetermined by adjustable stops, and it is therefore suitable for commercial-vehicle applications as well as for industrial and marine engine use. The two main portions of the unit are the Venturi air-flow control unit mounted in the induction pipe between the air filter and the engine, and the pressure-sensing unit which is mounted on the fuel pump and operates the fuel-control rack. These two parts are connected by an air-tight tube.

The operation of the governor is based upon the principle that air velocity across the end of a tube will tend to cause a pressure drop in that tube. In this case, the air velocity to the engine across the top of the tube is controlled by a butterfly valve in the Venturi unit, and the pressure drop set up in the tube is transmitted to the governor casing. The volumetric efficiency of the engine is not changed by the presence of the Venturi unit.

The governor casing is divided into two halves by a leather diaphragm, specially treated and prepared to render it extremely pliable. One half forms an air-tight chamber, with the exception of the tube connection to the Venturi, but the other half is open to atmospheric pressure. A light spring acts on the diaphragm, loading the fuel-control rack towards full fuel, and the balance position of the diaphragm under the action of the spring load and depression on one side and the atmospheric pressure on the other, locates the fuel pump rack so as to deliver the required amount of fuel to the engine. In its operation the spring also damps out high-frequency pressure variations, thus contributing to a smooth response. In order to stop the engine, a lever is provided which can over-ride the spring and move the fuel-control rack to the stop position. A small auxiliary spring is also housed in the governor casing to provide the necessary engine idling performance.

The engine speed is controlled within its limits by the lever operating the butterfly valve, which may be actuated by an accelerator pedal or other appropriate mechanism.



The Bryce A-size camshaft pump for small high-speed Diesel engines is now available with a pneumatic governor unit capable of controlling the engine at any speed between maximum and idling.

★ ★ ★

The first block of 75 compound underjet coke ovens, comprising half of a complete plant of 150 ovens with by-product plant constructed by Simon-Carves Limited, Cheadle Heath, Stockport, Cheshire, for Dorman, Long (Steel) Limited, at South Bank, Middlesbrough, is now in operation. The second block of 75 ovens is expected to go into service shortly. The 150 ovens will carbonise 25,000 tons of coal a week.

THE EXPERIMENTAL SPIRIT

5—LOCOMOTIVE WHEEL ARRANGEMENTS, BOOSTERS AND STREAMLINING

By C. R. H. Simpson, A.I.LOCO.E.

The fifth of a series of articles on unsuccessful experiments to make the steam locomotive competitive with electric and Diesel traction. The first four articles appeared on page 610, *November* 16, *page* 674, *November* 30, *page* 808, *December* 28, 1956, *and page* 81, *January* 18.

WHEEL ARRANGEMENTS

The number of unusual wheel arrangements which have been tried in Great Britain is small. Generally, types evolved many years ago have sufficed with the addition of a two-wheeled truck. Whereas overseas a wide firebox has almost always been employed in conjunction with a trailing truck, in this country a narrow firebox was used on the early Atlantics of the G.N.R., G.W.R., and L. & Y.R. and also on the first Pacific locomotive—the " Great Bear." The only examples of four wheels being employed were at the trailing end of Sir Nigel Gresley's No. 10,000—to be precise, two separate axles were used giving a 4-6-2-2 wheel arrangement—and two Atlantics rebuilt by the same designer as 4-4-4's, as illustrated. The engine and tender were articulated and part of the tender weight was carried by a trailing truck which was common to both engine and tender. Disconnection involved lifting the tender, and the scheme had the additional disadvantage that any tender repairs put the locomotive out of service. The only unique wheel arrangements, in addition to the foregoing, were the 0-10-0T locomotive built for the Great Eastern Railway by J. Holden in 1902, and the 0-10-0 Lickey banker of the Midland Railway. The former engine was designed to accelerate a 300 ton train from rest to 30 m.p.h. in 30 seconds—a feat which it succeeded in performing and which is perhaps still unique in British steam traction—but it was unacceptable from the civil engineer's viewpoint. The design was an extraordinarily interesting and able one; two points only can be mentioned here: the triangular connecting rod of the inside cylinder, so arranged to allow an axle to pass through it, and the evaporative heating surface of over 3,000 sq. ft., a figure unequalled before or since in British practice.

F. W. Webb's dislike of coupling rods is well-known and his uncoupled compounds exemplified it. D. Drummond also dispensed with wheel coupling in his class T7 and E10 4-2-2-0 four-cylinder simples, of which ten were built for the L. & S.W.R. contemporaneously with Webb's régime. These engines had a further feature in common with some L. & N.W.R. locomotives, namely the use of Joy's valve gear outside the frames. Both L.N.W. and L.S.W. classes were capable—on occasion—of high speeds, and both suffered from disturbances when the respective cranks got out of phase. As is well known, Webb's engines had drastic treatment at the hand of his successor but the Drummond uncoupled locomotives lived on until after grouping of the railways in 1922-23, the first engine having a life of some 30 years.

The use of boosters has sometimes left the wheel arrangement unaltered, but in other cases, e.g., the ex-Great Central Railway 0-8-4T, led to the coupling of the trailing axles: this matter is referred to under the heading of " Boosters."

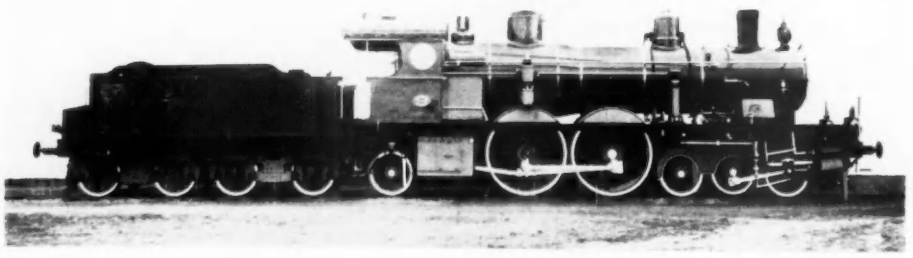
The 2-8-2 wheel arrangement had a limited and comparatively short life in Great Britain, despite a widespread application elsewhere, notably in America. Sir Nigel Gresley was again the designer responsible and first introduced this type in 1925 when he produced two P1 class mineral locomotives with three 20 in. by 26 in. cylinders driving wheels of 5 ft. 2 in. diameter. As originally built, these engines were fitted with boosters. These locomotives remained the only examples of their class, for they proved somewhat embarrassing to the Operating Department. As Mr. O. V. S. Bulleid has pointed out[92] the reason for withdrawal from the Peterborough-Ferme Park run, for which they were built, was that the train they were capable of hauling occupied three block sections and it was necessary to divide it at Ferme Park on a running main line before it could be disposed of. This difficulty was not without precedent on the G.N.R. for it will be recollected that Sturrock's engines fitted with steam tenders were capable of hauling trains in excess of the length of lay-by sidings.

Gresley's P2 class of the same wheel arrangement, as exemplified by " Cock o' the North," was at the time of its introduction, in 1934, the most powerful passenger locomotive in Britain. The class ultimately ran to six engines, differing in some respects, including valve gear and firebox design.

While some good performances were put up with heavy loads over the difficult road between Edinburgh and Dundee, the class could not be considered as successful, viewed from all aspects, and they were all rebuilt by E. Thompson. Mr. Bulleid has also pointed out that, in service, " Cock o' the North " was an extravagant engine owing to the fact she was not properly used. Owing to return workings the load at times was little above 200 tons and considerable standing time was involved. Thus while the coal consumption was heavy, most of it was burnt through misuse rather than in working trains.

Sir Nigel Gresley's continual search after knowledge was well displayed by his sending this engine over to France for test both on the test plant at Vitry and on the line between Orleans and Tours. On the track the horse-power developed was high—2,800. So far as the writer is aware the results obtained on the plant were never made public; but from a conversation, some years afterwards, with an executive of the test plant, there appeared to be no doubt that the engine had made a lasting impression!

Articulated locomotive and tender.



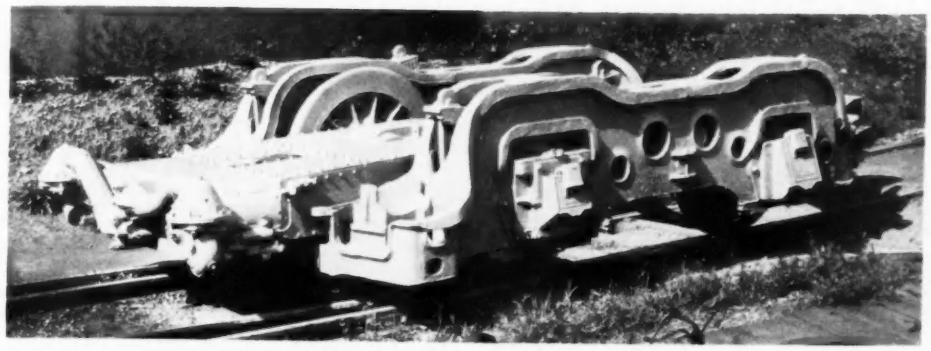
Bavarian locomotive with early form of booster.

BOOSTERS

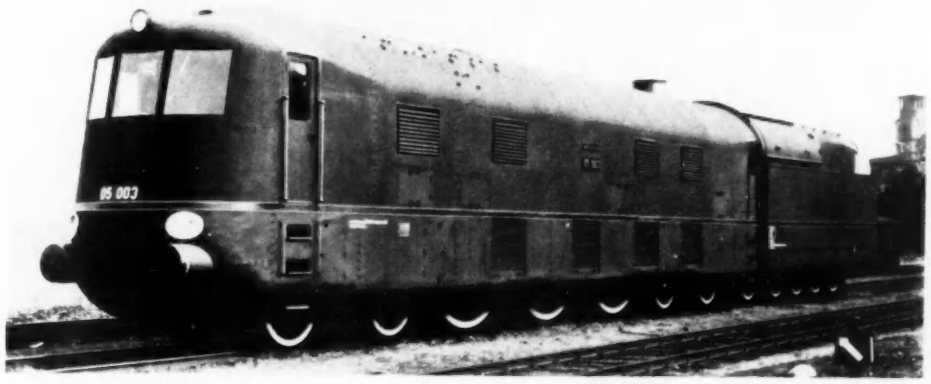
Boosters in the form of two-cylinder engines which drive wheels normally used for carrying, but which could be cut-in to augment tractive effort when starting or when extra power was required at low speeds, can trace their history in Britain to Archibald Sturrock's steam tenders, the first of which was built in 1863.[93] Some fifty engines were so equipped and the problems experienced, in the form of trains of unwieldly length and enginemen who objected to looking after what they regarded as two engines, are well known. There were also other difficulties, among them being the supplying of two additional 12 in. by 17 in. cylinders on the tender with wet steam from a boiler which had little reserve. The idea of a booster was revived in 1896 when Krauss and Company built a 4-2-2-2 locomotive for the Bavarian State Railways.[94] In this design the wheel pair between the trailing bogie wheels and the single driving wheels was driven by small cylinders housed below the normal outside cylinders. The axle was retractable. A basically similar idea was employed in the locomotive constructed by the same builders for the Bavarian State Railways and exhibited at the Paris Exhibition of 1900 (illustrated below). The auxiliary engines—as the device was described—had cylinders 0·26 m. by 0·40 m.

Boosters had a wide application, commencing in 1919, on trailing truck axles in America and also appeared under the name of " Auxiliary locomotive " when fitted to tender-trucks. The horse-power developed could be up to about 300 at 10 to 15 m.p.h.[95] The maximum cut-out speed was about 30 m.p.h. and it was possible —if properly handled—to cut-in at speeds up to 15 m.p.h.

British applications were few, and limited to the L.N.E.R. during Sir Nigel Gresley's tenure of office. Classes concerned were the P1 2-8-2, ex-G.N.R. " Atlantic," two former N.E. " Atlantics " rebuilt as 4-4-4's, and the former G.C.R. 0-8-4T, the last mentioned application involving coupling of the truck axles. In tests carried out with an " Atlantic " the tractive effort as built was 17,340 lb., and as fitted with a booster 25,840 lb.



Booster applied to bogie of an American locomotive.



German pulverised-fuel streamlined locomotive, 1937.

The maintenance—as was only to be expected having regard to the possibilities of engaging revolving gears under load—was high and the steam consumption was also relatively high. As Mr. O. V. S. Bulleid pointed out,[96] if the operating conditions were such as to require very hard working at high speed, it became necessary to increase the boiler capacity. The mechanical efficiency, steam consumption and power output of boosters were tested by Dr. Harvey N. Davies of the Engineering School of Harvard University.[97]

The 2-8-2's had sufficient power available without the booster and as it was regarded as unnecessary it was removed. The 4-4-4 rebuilds of ex-N.E.R. C7 class 4-4-2's, when boosters were fitted to the articulated bogies between engine and tender, rode badly, due to the large amount of unsprung weight; with the boosters removed, the riding was reported to be greatly superior to that of the engines in the original 4-4-2 condition.

So far as tender trucks were concerned, a typical application increased the tractive effort of a 2-10-2 locomotive by some 30,000 lb. An obvious disadvantage of tender trucks was that adhesion was lacking when the tender was nearly empty.

Boosters were examples of a device which may be popular with one department but not readily taken to by another. The traffic department welcomed ability to increase train loads, but the added complication and increased maintenance and first costs were not welcomed by the locomotive department. The popularity of the booster in America was perhaps partly due to the American freight train being close-coupled and requiring moving from a state of rest more or less en bloc, compared with its British counterpart where the load could be taken up progressively through the medium of loose couplings.

STREAMLINING

Although for many years V-fronted cabs, conical smokebox doors and other crude wind-cutting devices were tried, it was not until the 1930-1940 period that streamlining became fashionable in many parts of the world. No doubt the majority of applications had a greater value from the publicity angle than from the technical one. Streamlining can only become valuable, so far as power saving is concerned, at higher speeds, and to apply it to a locomotive which never attained the minimum speed necessary to show a saving may have impressed a small section of the public but a doubtful advantage was obtained at the considerable expense of greater first cost, increased weight (as much as 15,000 lb.),[98] and difficult maintenance. The classic case of such an application must surely be that to a 0-4-0 locomotive of the 2 ft. gauge Darjeeling-Himalayan Railway, the locomotive frame being lengthened "to improve the contour."

The saving in the horse-power required to overcome the head-on air resistance of a L.N.E.R. streamlined Pacific varied from 40·82 at 60 m.p.h. to 189·56 at 100 m.p.h. Since, in the pre-war years, to maintain the "Silver Jubilee" schedule entailed an average running speed of 80 to 90 m.p.h., the form of streamlining adopted by Gresley[99] on the A4 class engines resulted in a continuous saving of over 100 h.p. on a still day.[100]

It must be borne in mind that a locomotive does not lend itself to really efficient streamlining as it is not possible to enclose the underside. Even with the limited streamlining adopted, difficulty was sometimes experienced with axle boxes running warm. Until then it had not always been appreciated that the air stream passing boxes when running was conducting away some of the heat generated.

To-day the age of streamlining is over; many locomotives have had theirs removed in part or in toto. Aesthetically it improved some locomotives, especially those that were festooned with "plumbing"; it was also claimed in America that it afforded added protection in a collision, and it is a fact that sometimes the object collided with was deflected sideways, whereas without streamlining the results would apparently have been more serious.

Locomotive streamlining was yet another of the attempts at improvement which on balance did not justify retention.

An incidental advantage of streamlining was that it sometimes improved visibility. In at least one design (P.L.M. four-cylinder compound 4-4-2) it was noticeable that the steam which hitherto had beaten down on the cab was, after streamlining, kept well above it and also lost the tendency to splay out. On other locomotives, however, visibility was sometimes worsened.

To be continued

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CONSTANT SPEEDS AT VARYING TORQUES

Servomex Controls Limited, Jarvis Brook, Sussex, have recently placed on the market a high precision motor controller type M.C. 43. The equipment being expressly designed for rapid reversal, can be switched from full speed forward to full speed reverse in as little as 1·4 seconds and is thus eminently suitable for high-speed production work. A mechanical drive is provided in a convenient form, the speed range available being much greater than that obtainable with any other form of control. It is suitable for operation from a mains supply of from 200 to 250 volts single phase at 50 to 60 c.p.s., and provides speeds from 0 to 6,000 r.p.m. which can be smoothly varied in either direction. An electrical tachometer on the control panel enables the operator to determine the motor speed with an accuracy of plus or minus 1·5 per cent. of full scale. The torque produced is a minimum of 21 ounce-inches at all speeds and does not diminish at the higher speeds. A feature of the instrument is that the application of full torque does not cause a speed change of more than 6 r.p.m. over the whole range of speeds. Also, at constant torque, mains variations of up to plus or minus 7 per cent. of the nominal voltage and frequency do not cause a change in speed greater than 5 r.p.m.

The system is basically a direct-current motor, with an approximate output of ¼ b.h.p. at 6,000 r.p.m., to which is coupled a direct-current tachometer-generator specially designed to give an output voltage accurately proportional to speed. The generator voltage is compared with reference voltage and the discrepancy amplified and used to increase or decrease the speed of the drive motor until the error is eliminated. The speed error cannot exceed a few r.p.m. for more than a matter of milliseconds, and a suddenly applied load is normally compensated for in about one-twentieth of a second. No electrolytic capacitors are employed. If required, provision can be made for a remote speed controller. For certain applications requiring a range of different pre-set speeds, a switch, which can be either manually or automatically operated, can be provided to select these. The control unit is mounted on a standard 19 in. rack panel of 14 in. height; the depth is 15½ in. and weight 88 lb. A 12 way flexible cable 6 ft. in length connects it to the motor, which is suitable for foot or flange mounting. The weight of the motor is 7¾ lb.

HIGH-SPEED MECHANICAL INDEXING

750 or More Movements a Minute

Mechanical indexing of machine parts has been achieved for many years by a number of well known mechanisms which, in spite of inherent functional limitations, have performed satisfactorily in countless applications. Modifications of common indexing mechanisms have been developed from time to time to overcome one limitation or another imposed by the basic design, and these, again, have had their uses, though they have often represented a compromise. They provided the mechanical movement desired, but they were no longer the simple mechanisms which have such obvious advantages in the matter of initial and maintenance costs.

In recent years a new demand has been made on indexing mechanisms, which the older types have been unable to meet, and new devices have had to be developed. One of the newer, though fully-established, indexing mechanisms, made by the Manifold Machinery Company, Limited, 660 Great Cambridge-road, Enfield, Middlesex, is shown in Fig. 1. The method of operation of this mechanism which is known as the Manifold Mark I index gear, is obvious from the illustration. It offers an almost unlimited choice of ratios of indexing time to dwell period, and enables the machine designer to use almost any pattern of acceleration and deceleration according to requirements. The design is such that the cam and roller followers are always in contact, so the mechanism is self-locking. This mechanism has been used to give cycle times ranging from ¼ second upwards on turrets with from 8 to 72 stations, and weighing from a few pounds to more than 10 cwt.

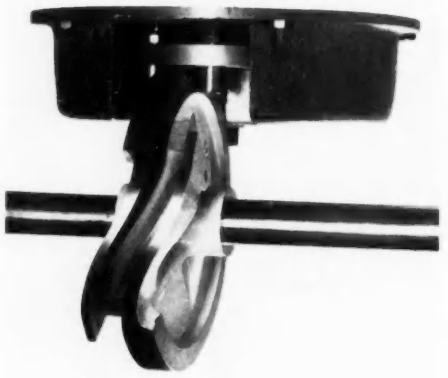

Fig. 1 Manifold Mark I index gear, giving cycle times from ¼ second upwards.

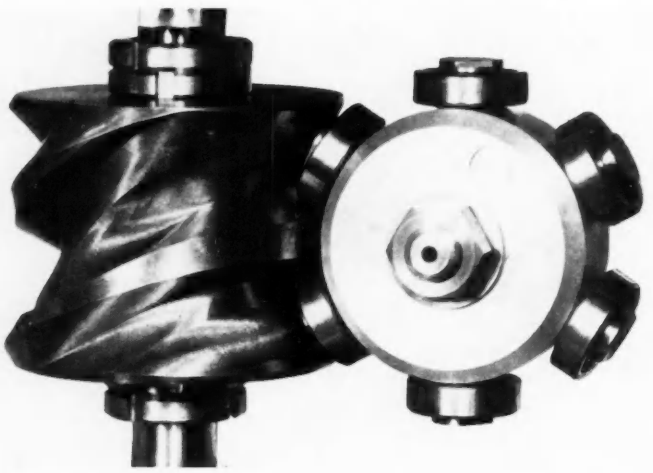

Fig. 2 Using the same basic principle, the Manifold Mark II gear gives very high speed indexing; 750 or more movements a minute are possible.

A second mechanism, known as the Manifold Mark II, which is in effect an "opening-out" of the Mark I, has now been introduced. It is shown in Fig. 2, from which it will be seen that the roller followers are mounted radially. There is greater clearance between the rollers for a given pitch diameter, and as a consequence it is possible to use standard ball bearings instead of specially-made tapered roller followers. Ball bearings have the obvious advantage of reducing the overall friction within the indexing system; they are also cheaper in first cost than special rollers, and can be replaced from stock at any time.

The increased roller clearance in the Mark II gear also facilitates indexing on machines having less than eight stations, which is the minimum conveniently handled by the edge-cam and roller gear.

Indexing periods ranging between 25 and 100 per cent. of the cam revolution can be selected as required, and the Mark II mechanism will give 750 or more operating movements per minute, a speed which is in excess of most commercial applications at present. Accuracy is governed by the angular location of the roller followers, and as the mounting holes for these rollers are produced with the aid of optical dividing heads, the location of the turret head during dwell periods is maintained to a similar degree of accuracy.

As the illustration shows, the mechanism of the Mark II gear is all in the indexing plane, and it is thus possible to reduce the overall size of the unit without sacrificing its strength. The three-dimensional cam with its helix of varying pitch angle, which can be seen clearly in Fig. 2, is the only part of the complete mechanism which does not lend itself to production by standard machine tools. The manufacturers of the indexing gear propose to make this cam on a specially built cam-milling machine, using an automatic continuous process.

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GUN-REAMING PRECISION COMPONENTS

An adaptation of the gun-drill method to the accurate reaming of pre-drilled holes in high-tensile steel components used in aircraft construction has been developed by Short Brothers and Harland Limited, Queen's Island, Belfast. The new method imparts a high standard of finish.

The standard practice of reaming high-tensile steels with a tool having spiral cutting edges is a laborious method which does not produce holes of consistently high finish. Expensive components are often badly scored and have to be scrapped, while maintenance of the tools is costly and difficult; they may have from four to eight cutting edges, each of which has to be reground separately.

In the new method, the tool employed has a single tungsten carbide-tipped cutting edge, supported radially by two stabilising wear pads which ensure that the hole is reamed to consistently accurate dimensions. It represents a considerable advance on the older type of gun drill in that only a single reaming operation is necessary.

The gun-drill technique, it is claimed, can perform reaming operations 40 to 60 times faster than standard methods, resulting in an average saving of up to 98 per cent. in its annual overheads for reaming operations. The design of the gun reamer has been so simplified that it can be made in any toolroom which has a lathe, a milling machine and facilities for tip-brazing. Maintenance presents few problems, for the tips—unlike those of standard carbide reamers—are large enough to be handled without difficulty, and there is only one cutting edge to be re-ground.

Apart from the very fast production rates possible with gun reamers, they are also capable of producing holes of high standard even when used in poor or indifferent machines. Thus, any machine operating in a shop may be used for important work normally executed only on the best machine available.

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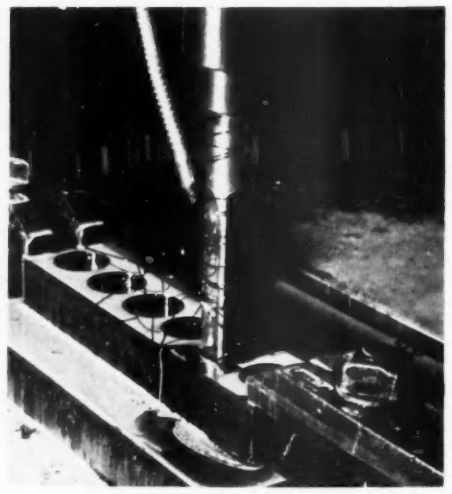
BRITANNIA FUSELAGE FIRE PROTECTION

The Bristol Britannia air-liner has been equipped with a fuselage fire-protection system developed by the Pyrene Company, Limited, 9 Grosvenor-gardens, London, S.W.1, with B.O.A.C. and Bristol Aircraft, Limited. The system is to be fitted as standard fire-safety equipment aboard B.O.A.C.'s fleet of Britannia aircraft which go into regular passenger service on February 1. Similar equipment is to be installed aboard the Britannia aircraft ordered by Northeast Airlines.

Immediate warning, both audible and visual, of the presence of smoke is registered on the flight deck by Pyrene photo-electric aircraft smoke detectors which are located at the air spill valves. The detector units weigh only 2·9 lb. and their small dimensions enable them to be installed in points of the aircraft not accessible in flight. A test circuit and reset switch are fitted to facilitate checking of the equipment at any time.

The actual compartment affected by fire is located by a visual smoke indicator which works in conjunction with the smoke detector. Upon receipt of an alarm signal from the detector, a suction mechanism is brought into operation and draws air from the protected spaces. The presence of smoke is indicated by means of a white light within the appropriate inspection window of the indicator.

Fire-extinguishing equipment includes three



A new type of gun reamer employing a single carbide-tipped cutting edge is seen here reaming holes of 1½ in. diameter in a 55 ton steel at 600 r.p.m. and 0·008 feed.

carbon dioxide Duo-head fire extinguishers, two of which are arranged to provide automatic flooding of the wing roots with inert gas under emergency landing conditions. Each of the three extinguishers contains 11 lb. of liquified carbon dioxide which, on discharge, produces 90 cub. ft. of gas. Alternatively, these units may be speedily plugged into pipelines so that the gas may be discharged by hand into selected freight compartments. Where necessary, they may be used as portable fire extinguishers against accessible fires. Carbon dioxide selector valves enable the operator to direct the gas discharge to the affected compartment when required and automatically render the compartment airtight, so that the inert gas does not escape, and effective fire control is secured.

Two carbon-dioxide hand fire extinguishers are provided for flight-deck protection. These extinguishers are each charged with 2¼ lb. of CO_2 gas in liquid form and fitted with a pistol-grip operating head embodying a trigger-type shut-off valve and a diffusion applicator. A light-alloy bracket holds the extinguisher securely against acceleration forces of up to 25*g* in any direction, although release of the extinguisher for operational purposes is effected by the movement of a single lever.

A simple fire drill for freight holds and accessory bays has been evolved. Upon receipt of a fire warning from one of the two smoke detectors, operation of the visual indicator shows which compartment is affected by fire. The corresponding carbon dioxide selector valve is then operated to select the required Duo-head fire extinguisher and automatically close the air ventilation to the compartment. The fire extinguisher is then operated by hand to flood the compartment with a fire extinguishing concentration of carbon dioxide gas.

DRYING PAINT ON COMPLEX SHAPES

INFRA-RED HEATING DIRECTED AT SPECIFIC PARTS

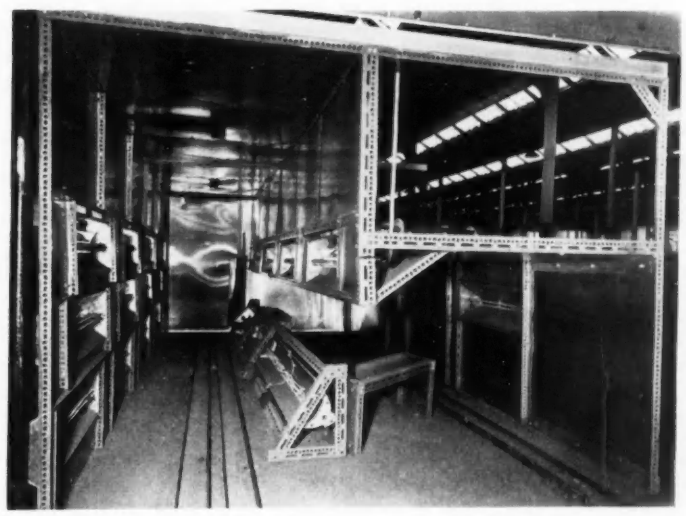
Infra-red heating can be used to speed the drying of paint applied to quite complicated machinery after assembly by arranging the elements to bear on specific parts. But to avoid having to heat the surface of a large mass of metal to the high temperatures required for hardening stoving enamels, air drying synthetics are used. The finish obtained with these paints is very much improved by forced drying, and drying times of a few minutes can be obtained.

At the Uttoxeter Works of Bamfords Limited, paint on agricultural machinery is being hardened in infra-red plants which use sheathed-wire elements as the source of radiation. The elements are mounted in aluminium reflector units and the plants are enclosed with aluminium sheeting having inner reflecting surfaces. The arrangement for the side rake and swath turner is shown in the accompanying illustration.

The machine is completely assembled before being painted. It is moved on its own wheels from the spray booth into the infra-red plant where its position is fixed by guide rails. The plant, which is mounted directly on the floor, is L-shaped, the taller section accommodating the side raking reels.

In the latter section there are 22 sheathed-wire element reflector units designed and supplied by the General Electric Company, Limited, some mounted in the sides, others on the floor and one in the end door. Six more reflector units are positioned in the smaller section of the plant where part of the tubular framework is dealt with. The maximum loading is 84 kW. The heating time is six minutes, but some of the reflector units providing radiation to the reels are switched off automatically after only four minutes.

Infra-red heating is also used in the finishing of the Bamford-Long automatic pick-up balers. Two plants are used, one to speed the hardening of the primer coat, the other to deal with the finish coat. These two plants and the two paint spray booths are arranged in a continuous line with guide rails running the whole length. The balers are not completely assembled before painting but the main body and the baling chamber are finished together, the latter being mounted in a convenient position above the body. They are moved through the finishing process on bogies.

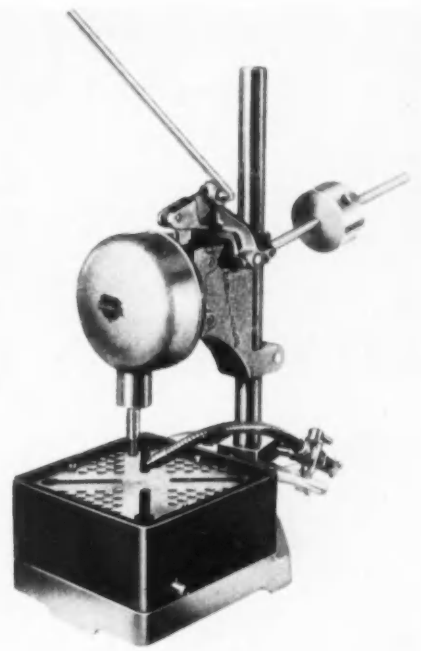


Infra-red elements can be arranged to bear on all parts of complex machines to dry the paintwork. In this case the wheels of the side rake are guided by the three sets of channels as it passes through the oven.

MINIATURE TELEVISION CAMERA

It has been found that, to obtain the fullest information on the behaviour of the fuel rods that supply the heat in a nuclear power station, a television camera provides the most effective method of carrying out routine internal inspections.

A new camera, by Pye Limited, Cambridge, is only 3 in. in diameter and 24 in. long, so that it can form part of the mechanical grab which will be lowered into the fuel channels of the graphite core to remove possible obstructions. The focus for this particular camera, which carries its own source of illumination, is pre-set before it is inserted in the reactor. The camera is stated to have been designed and manufactured in four weeks. (See ENGINEERING, vol. 181, page 282, 1956.)



New accessories for the 50 watt ultrasonic drill are a series of matching stubs, giving increased amplitude gain, and a combined work-table and abrasive circulator.

ULTRASONIC DRILL ACCESSORIES

The scope and performance of the low-power ultrasonic drill made by Mullard Limited, Mullard House, Torrington-place, London, W.C.1, have both been increased by the production of new accessories. These are: first, a slurry pump and work-table, which can be supplied with the drill or purchased separately for attachment to existing intallations; and second, a range of matching stubs of new design which increase not only the speed of drilling but also the capacity of the drill. A unit with these accessories is shown in the illustration.

The slurry unit incorporates an immersed impeller pump, thereby avoiding the use of glands with their risk of leakage. The reservoir tank is shaped to reduce build-up of the abrasive, which is agitated into suspension by by-pass jets from the pump. Wherever necessary hardened materials have been used to reduce wear. The outlet to the workpiece is controlled by two-way cocks which direct the slurry on to the work or by-pass it back into the tank. By this means the abrasive is continually circulated and not allowed to settle in the pipe-line.

The top of the work-table is constructed so as to ensure that the abrasive falls into the lower compartment without serious interruption, from whence it is flushed by sprays and jets into a large-bore return pipe. In all cases, water-abrasives at a concentration of approximately 100 : 1 and containing a rust inhibitor should be used. The pump unit measures 11 in. by 6 in. by 18 in. high. It has a capacity of ½ gallon of water which would contain approximately 3 lb. of abrasive. The power consumption is about 100 watts and the unit can be run from standard mains of 110 or 250 volts, 50 c/s. The work table measures 7½ in. by 7½ in. by 3½ in. high.

The new matching stubs are of stepped cylindrical construction, and give an amplitude gain equivalent to the square of the ratio of the end diameters. Exponential stubs, which have hitherto been used, give a gain which is equivalent only to the simple ratio of the end diameters. Four stubs comprise the new range, two having top diameters of ¾ in. and two of 1½ in. with tip diameters of ¼, ⅜, ½ or ¾ in. so that amplitude gains of 9 and 4 are available for each top size. It is claimed that, with these stubs, the cutting speed can be increased and larger tools used.

SPARES AND SERVICE DEPOT

2,000 ITEMS HANDLED A DAY

To cope with the increased demand in a spares service which has grown very rapidly since the war, Ruston and Hornsby Limited, Lincoln, have developed a department, separate from the ordinary production side, devoted entirely to this matter. Stocks of spare parts are ordered from the production departments as particular orders and therefore supplies are maintained according to the requirements of the service department. In outline, the parts on arrival at the spares building are checked for type, number and dimensions and then coated if necessary with a rust-preventing skin before being taken by conveyor belt to the various bins in the stores. Where sub-assemblies are supplied complete, assembly is carried out before the parts go into store. This saves time when the sub-assembly is ordered as a spare part.

The stores building is divided into two main sections, in one of which the heavy parts weighing more than about 100 lb., and also those which are of awkward shape, are stored on pallets mounted on steel racks and the other, which is on three floors, for the smaller parts which can conveniently be stored in bins. The conveyor system traverses all three floors, and a control on each of the trays determines where the load on it is delivered. As the tray passes the unloading station, a stationary arm engages with a roller which, in turn, tilts the tray so that the box containing the parts slides off and down a chute. This is occurring in Fig. 1. The station can be selected by turning a dial which adjusts the position of the roller as shown in Fig. 2. In the event of a chute becoming over-loaded due to the absence of the storekeeper on other business, spring contacts provided at the head are depressed by the last load delivered, so stopping the conveyor and preventing accidents due to a following tray hitting the projecting box. Parts for delivery are placed by the storekeepers on the same conveyor and are deposited on chutes in the dispatching section in the same manner as in the stores. The larger parts that are normally stored on pallets cannot be handled by the conveyor, and a battery electric fork-lift truck is used for moving them. To save time in handling, the pallets are not necessarily returned to their original positions, but are replaced in a convenient empty space. This involves a movable position record system from which the whereabouts of any particular item can always be ascertained. The method developed employs tabs, colour-coded and numbered, which are hung on hooks on boards corresponding to the pallet racks. When the storekeeper wants any particular item, he refers to these tabs and removes the one in question. After the pallet has been replaced by the truck operator, the identifying tab is hung on the hook corresponding to the new position.

It is the aim of the department to be able to produce spares for any engine up to 25 years old directly from bins, and also parts for engines older than this for which there is known to be a regular demand. (A part is considered to be in demand, and is therefore kept in stock, if four or more requests are made for it during a year.)

The file records go back to 1894, and although it is not possible, of course, to guarantee that some particular part required for these older engines is immediately available, there are facilities for constructing it if necessary. When an order for spares is received, it is sent up to the main office, and is there printed on a standard form and the reference and drawing numbers for the particular items are added. A sufficient number of copies is then printed off to supply advice notes, invoices and records, and then requisition slips for each separate item on the order are printed off automatically, together with a stock label for attachment to the part by the storekeeper. The requisitions are passed through the stores stock room and are delivered by gravity chutes to the floors on which the particular bins containing those parts are situated. The storekeeper then merely collects the requisition from the chute, selects the part from the bin, and places it in a box on a tray of the conveyor. On arrival at the dispatching section, the part is again checked against the original order and is then packed for delivery.

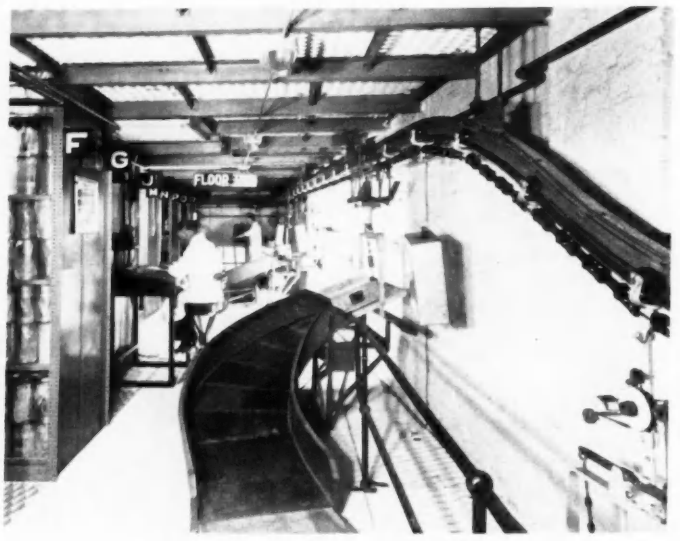


Fig. 1 The smaller parts are delivered to and from the stores by a conveyor system which traverses all three floors.

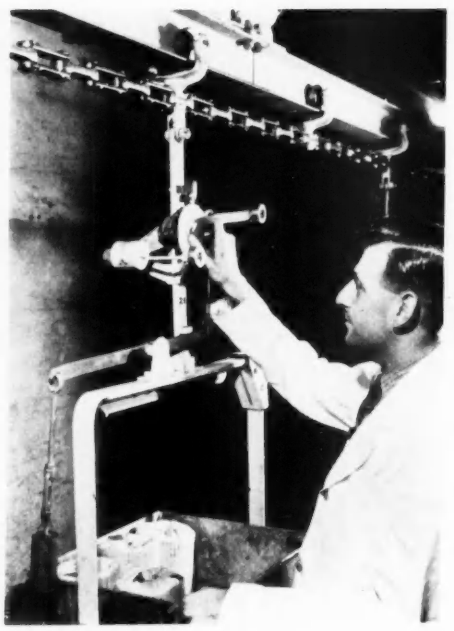


Fig. 2 The point at which the trays of parts are discharged on to the chutes is selected by adjusting a dial on the conveyor tray.

In the packing department as much use as possible is made of folding cartons and boxes. Some of the boxes are made from thin wood sides with metal corner pieces and can be used many times. Whenever possible use is made of standard sized packing cases, again with a view to economy. A strapping machine has been introduced for the cartons and the boxes with adjustable tension so that relatively delicate parcels are not crushed.

One of the problems of any spares department is the question of stock control. At Ruston's this has been dealt with in the following manner. Every month the demand for each part is reviewed and the maximum and minimum stock of that part is adjusted to suit. It is always reckoned that the minimum should not be less than a three months supply. Such control is particularly necessary in the case of those parts—obtained from other firms for which delivery dates are long or even uncertain. The close and regular review of demand also gives a good indication if any particular part is giving undue trouble. This is particularly useful in the case of new engines, and can be used as a guide to design modifications. It can also be used as a check on the efficiency of packing, for a continued demand for a particular part on newly supplied engines might well indicate that damage was occurring in transit. Consequently, all demands are totalled and recorded on a monthly return sheet which is circulated to the sections concerned. Records are also kept of visits by service engineers, who make "courtesy" calls as well as going to places where trouble has been reported. These records often form useful guides when later visits are made.

In the records department use has been made of microfilms to save storage space, which is very necessary in view of the enormous amount of information that has to be filed. Some 70,000 orders are received every year, each consisting on an average of eight separate items; so the volume of paper work involved is considerable. The stores contain between 40,000 and 45,000 different items ranging from hot bulbs for the engines of 1894 to parts for gas turbines. As a separate section of the organisation an engine exchange system is in operation for all types of engine up to 50 h.p., with, in addition, the 165 h.p. engine used in shunting locomotives. A special "short cut" system has been evolved for use when customers call directly at the works for spares, which enables them to be supplied on an average within 20 minutes; in many cases much more quickly. The formalities are then completed later so that the records shall be correct. As with all such systems, the last mentioned is of vital importance.

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ELECTRICAL INSPECTION

It was the object of the newly formed National Inspection Council for Electrical Installation Contracting to begin functioning on January 1, 1957. Progress was, however, delayed by the death of Mr. P. V. Hunter, the first chairman of the Council. His place has now been taken by Mr. C. R. King, chairman of the East Midlands Electricity Board, who had previously been elected deputy chairman, while Mr. A. F. Plummer, of Shoolbred Electrical Company, Limited, Luton, has been appointed to fill the vacancy thus caused. Mr. E. J. Sutton has been appointed chief technical officer of the Council. An establishment of 14 inspecting engineers has been approved and the positions have been filled in the 12 areas into which England has been divided. It still remains to appoint two inspecting engineers for Scotland.

Work is also proceeding with the preparation of the first roll of approved installation contractors. It is proposed to issue this in geographical and alphabetical sections and to publish both by March. Many inspections of new applicants for enrolment have been carried out.

Marketing

HIGHER EXPORTS FORECAST

The volume of exports is expected to rise by 3 per cent. this year. No change is predicted in the levels of industrial production, consumer spending and the volume of imports and there should therefore be a surplus in the United Kingdom balance of payments. There is also a unanimous expectation that interest rates will fall and that the Bank Rate, by June, 1957, will be 5 per cent. or less.

These forecasts were made in answers to a questionnaire sent to their members by the Business Economics Group (ENGINEERING, page 63). The replies received were from a very wide range of industry, commerce and Government departments, and they should therefore be representative of informed opinion.

Earlier this month American economists, gathered together at their annual convention at Cleveland, found that they needed " to give more attention to the problems of prosperity." Inflation, in all its forms, was the leading topic for discussion. There was general agreement that " a serious decline in the economy is most likely to come from an inability to curb inflation," and that economists, or politicians, really knew very little about the effectiveness of economic controls under such conditions. No one predicted a slump but most found prosperity rather baffling.

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Setting the Standard

The difficulty of interpreting users' requirements when setting quality standards in engineering components is appreciated by most managements. In a paper presented at the Winter Proceedings of the British Institute of Management—" New Fields for Quality Control "—Dr. R. M. Belbin points out that the skilled examiner or the technical expert have " too great a knowledge of faults in the material or product" and tend " to see faults that customers would never see." He quotes the instance of an old customer from overseas visiting the final inspection department of a manufacturer of sheet material. Having examined with great care the top sheet of a pile of rejects he said " Now this is perfect, why can't you send me stuff like this? "

Dr. Belbin's research established that the faults looked for by the manufacturer's inspectors and by his customers are seldom the same. This can be a most serious source of waste since the more complaints a manufacturer hears, the stricter the quality standards he will impose—in respect of those faults which he considers matter most. The proportion of scrap is therefore increased without necessarily reducing the flow of complaints from the customer. Dr. Belbin's evidence suggests that, even among leading suppliers of engineering components, " a considerable proportion of customer's complaints and returns relate to defects to which attention has not been drawn in final dispatch."

The evidence put forward in this paper—the techniques proposed for maintaining a standard are reported elsewhere in this issue, on page 107 should be most carefully studied by managements, both from the viewpoint of establishing company standards which are in line with customers' requirements and of defining requirements clearly and precisely to the company's suppliers. Also, there is a strong case for not awaiting definitions from customers but finding out without delay the faults they look for and for what reasons.

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Air Compressors in Africa

The merger of Broom and Wade and Holman Brothers (Weekly Survey, January 11) into what is possibly the largest maker of air compressors and pneumatic tools in this country, with excellent facilities in South Africa, has been followed by announcements from two of their competitors concerning the African market. The Consolidated Pneumatic Tool Company, Limited, who still claim to be " Britain's largest manufacturers of air compressors and portable power tools " have set up direct representation in Southern Rhodesia. A new company has been formed with head offices in Bulawayo to secure an expansion in the sales and service facilities offered by Consolidated Pneumatic proportionate to the " large industrial development in these areas."

The Swedish firm Atlas Copco, who claim to be " the world's largest group of compressed air engineers " have established a company in the Belgian Congo with headquarters in Elisabethville. This is the centre of the Union Minière du Haut-Katanga, one of the major producers of copper and uranium. The company mention the establishment of a mobile repair shop and demonstration van, to secure good after-sales service so essential in a country of great distances and difficult terrain.

The pace of industrial development in Africa, from the Atlas Mountain range to the copperbelt has increased greatly in recent years, and everything points to the continent becoming in a relatively short time the major source of mineral imports for the Western hemisphere.

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Factory Equipment at Earl's Court

The 1957 Factory Equipment Exhibition to be staged from April 29 to May 4 will be a test of industry's attitudes to further expansion. There are no signs so far that interest will be less than in any previous year. The 250,000 sq. ft. have been fully booked by 300 manufacturers who include some overseas companies. This is a post-war development, the first having been held—on a relatively very small scale—at the Royal Horticultural Hall in 1953.

The theme of the exhibition is to be " greater efficiency in industry " and control instruments will be prominent. There will be demonstrations of mechanical handling equipment of all types and there will therefore be some considerable overlap with the Mechanical Handling Exhibition held during last May. There will be, none the less, a wide variety of exhibits outside the mechanical handling field, including packaged boilers, steam-raising and space-heating plant, as well as equipment designed for fuel economy.

The British Productivity Council, which will be exhibiting, have organised a three-day conference at Earl's Court from April 30 to May 2. Other professional bodies holding conferences during the exhibition are the Incorporated Plant Engineers and the Institute of Materials Handling. The Royal Institute of British Architects, the Fire Protection Association, the Gas Council and the British Electrical Development Association will also be represented.

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Mission to Canada

The amazing rate of growth of the Canadian market is continuing to attract the attention of British manufacturers. The Dollar Exports Council announced last week that in view of the continuing expansion of the constructional industry, it has organised a delegation to visit Canada in March to make an on-the-spot check of the prospects of increasing British exports of building materials and allied products.

Mr. Halford Reddish, chairman and managing director of the Rugby Portland Cement Company, will lead the delegation. The other members are Mr. A. Atha, a director of Guest, Keen and Nettlefolds (Midlands), Mr. R. S. Jukes, managing director of British Plaster Board (Holdings), and Mr. H. E. Peirce, managing director of Hall and Company, Limited, Croydon, Surrey.

Another note on this page discusses the opportunities for British manufacturers in Africa and the steps taken by some to improve their representation and service facilities in that continent. Yet many manufacturers fight shy of the Canadian market and have to be persuaded even to visit the country to see for themselves the excellent opportunities that exist. It should not be necessary for the Dollar Export Council to organise " a check of the prospects " by top-level industrialists.

It is to be assumed that Mr. Reddish and his colleagues will go to persuade themselves, and the other members of their industries who will await their report, that the opportunities mentioned by the D.E.C. are real ones. The mission may, of course, not only look at the Canadian market but take active steps to promote their industries' interests.

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Chains, Belts and the Future

A mixture of realism and pessimism makes up an interesting and unusually forthright report to the shareholders of J. H. Fenner and Company (Holdings) by their chairman, Mr. C. Bradshaw. His analysis of the prospects of Britain and British industry is roughly as follows: high taxation of profits, high welfare costs, tendencies on the part of overseas markets to supply their own needs, the lack of any particular geographical, geophysical or meteorological advantage, the Monopolies Act and political ineptitude all add up to eventual bankruptcy. " It is becoming clear that many companies with international connections are beginning to look for other places in which they can operate." The promising young men leave the country, and will go on doing so for as long as they cannot get the attractive prospects they need at home.

Fenners are probably the largest makers of power transmissions (using chains and belts) outside the United States. The group are concerned with products the demand for which arises from general industrial activity in the broadest sense. For this reason Mr. Bradshaw's analysis of demand trends is valuable. He foresees greatly increased competition in the home market, partly because his company and their competitors have considerably increased capacity in the past few years, and partly because he foresees a considerable falling off in new factory construction and therefore " a period during the current financial year, and possibly the next year, too, when new factories are not being built and new machines not being bought and installed." The prospect of increased capacity and a non-expanding or a contracting market is not welcomed, but Mr. Bradshaw believes that his company are " in a good shape to undertake " the inevitable struggle.

Few would go the whole way with Mr. Bradshaw, either in his assessment of industrial activity in the home market or his suggestion that local manufacture overseas prevents British exports. Experience shows it can have the opposite effect and, further, that Britain can keep ahead technically and continue exporting.

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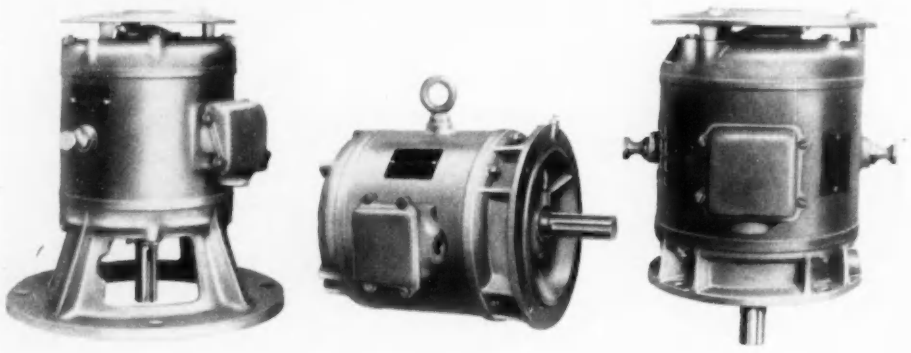
Recovery in the Air

This highly sensitive barometer of consumer spending on household appliances, second-hand car prices, has been rising since Christmas. The prices of popular models of recent date (1953 to 1956) were 10 to 15 per cent. higher in the second week of January compared with those recorded in the early part of December. Small cars were particularly in demand, such as the Morris Minor, Austin A30, Ford Popular, Anglia and Prefect. Petrol rationing could, of course, have been the underlying factor in this recovery since many owners of large cars have sought to supplement their ration by purchasing a small one (unlikely to depreciate violently).

But there is evidence from other sources that demand for radio and TV sets, washing machines, refrigerators and other appliances is rising again.



Typical examples of Crompton Parkinson Series 5 ventilated squirrel-cage motors in which many improvements have been incorporated.

STANDARD ALTERNATING-CURRENT MOTORS

SMALLER AND LIGHTER DESIGN

The photograph reproduced above shows examples of a new range of standard ventilated three-phase squirrel-cage motors, which are now being manufactured by Crompton Parkinson Limited, Aldwych, London, W.C.2. They are known as Series 5 and are available in outputs from 1 h.p. four-pole to 50 h.p. two-pole. From left to right in the illustration, the vertical-spindle skirt base, the horizontal-spindle flange mounting and the vertical-spindle flange mounting types are illustrated; foot-mounted types are also available.

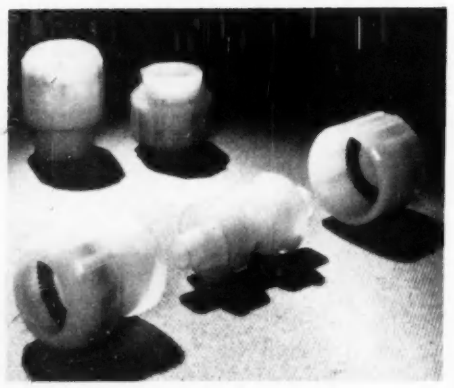
In designing these new motors Crompton Parkinson have utilised, as is now permissible, Class E insulation, which allows for operation at continuous maximum ratings with a temperature rise of 65 deg. C. This, coupled with the development of a more efficient cooling system, has enabled the size and weight of a motor with a specific horse-power rating to be reduced and the form of standard protective enclosure to be improved. Compared with the machines they supersede the new motors may be as much as 40 per cent. lighter and take up only 60 per cent. of the space.

The new motors are of a radially-ventilated design, whereby cooling air is drawn in through the lower portions of both end-shields and is directed by baffles over the bearings and towards the centre of the machine. It is then passed radially outwards over the end turns between the core and the shell and finally escapes through openings in the sides and bases. With this arrangement it is claimed that although the motors may be operated at a temperature up to 65 deg. C. above that of the surrounding atmosphere the outer shells will not become dangerously hot and the bearings will become no hotter than those on motors designed for temperature rises not exceeding 55 deg. C. A further point of interest is that the low velocity and diffusion of the air discharged is such that personal discomfort is not experienced by machine operators working nearby.

The fans, of which there is one at each end, are integral parts of the rotor and the baffles, which direct the cooling air, also serve as protective shrouds over the end turns, so that it is impossible to touch the windings from outside the motor. The end shields, which are identical at each end, are of solid construction and provide more protection than the standard screen type which they supersede. The stators, while of the same cast-iron construction as the end shields, have their windings insulated with synthetic enamel and the slots with liners of polyester films on leatheroid. The finishing of the end turns, the coil ends and any welded joints are also carried out with modern materials.

The rotors of the smaller motors are die-cast and this practice is also being progressively extended to the larger machines. The bearings are either ball or roller or a combination of the two, depending on the output; and a small but useful innovation is the adoption of unified threads for all the screws employed in construction.

The new motors have the same dimensions as those laid down for equivalent N.E.M.A. frames, except that the British machines have slightly l rger diameter shafts to cater for the higher outputs developed in the same sizes of frame.



The " Bowdenfix " coupling is made of nylon and can be used to join a hose to a fixed point or to connect two lengths.

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NYLON COUPLING FOR PRESSURE HOSE

A high speed coupling for pressure hose is now available in this country through Bowden (Engineers) Limited, Willesden Junction, London, N.W.10. It is made of nylon and in two forms, one for coupling the hose to a fixed point, and the other for connecting two lengths. Both types are shown in the illustration.

Briefly, each " Bowdenfix " coupling consists of an insert over which the end of the hose passes, and a screw nut which is tapered internally and contains a locking spring. As the nut is tightened, the spring is brought to bear on the outside of the hose and forms a tight joint capable of resisting pressures up to approximately 200 lb. per sq. in. For a given inside diameter of hose, widely different outside diameters can be accommodated by the same coupling, and fixing takes only a few seconds. No special tools are required for attachment, and, being made of nylon, the coupling resists rough usage extremely well. Couplings for hoses up to 1 in. internal diameter are now available.

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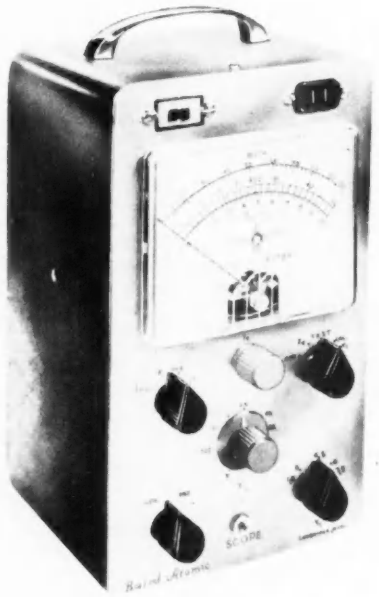
TRANSISTOR TEST SET

A new portable test instrument for measuring transistor parameters has been introduced by Baird Associates—Atomic Instrument Company, Cambridge, Mass., U.S.A. The instrument is noteworthy owing to the fact that it uses transistors throughout. It is completely self-contained having its own 1 kc/s oscillator and mercury-cell power supply. The battery life of the mercury cell is about 1,000 hours. The model KT-1 has been designed to measure the current gain in the grounded emitter connection δ, the short-circuit input impedance δ, and the collector saturation current δ, for various emitter currents and collector voltages.

The instrument, shown in the illustration below, is 10 in. high and weighs 3 lb. Printed-circuit techniques have been used throughout.



Instrument for testing transistors, itself operated by transistors.

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SEQUENCE TIMER

The new Rodene self-resetting sequence timer, type 2600, distributed by D. Robinson and Company, Worcester Park, Surrey, is intended for such purposes as starting slip-ring motors, re-closing circuit-breakers, and controlling any sequence of events that must occur at predetermined times after a starting signal. There are two standard models. One can run for up to 15 seconds and control up to four circuits; the other runs for up to one minute and controls up to eight circuits. The drive is provided by a self-clutching, inherently forward-running, Rodene synchronous motor. Each circuit has a 5 amp. snap-action switch operated by a pre-set cam. The operation is such that when the shaft has turned through 300 deg. it is stopped and held; interruption of the motor supply at any time will cause a spring to drive back the shaft to the start position. Alternative models can either run continually without resetting, or turn through 360 deg. and then stop until a switch is changed over, when it will make a further revolution. These units can have speeds as low as one revolution per week.

ATOMIC REVIEW

Power Plus

More signs of an expanding programme—Group prepared to undertake both home and overseas power reactor contracts—Company formed to machine graphite—Berkeley reactors—Potential exports—Cold fusion: advantages and disadvantages—Papers on thermonuclear fusion—Criteria for fusion reactions—Rates of reaction—Pulsed gas discharge—Proton properties—Tanker and submarines—Heat from reactors—Indian establishment—Uranium supplies—B.N.E.C. admits metals institutes.

Programme Expansion

Towards the end of last year it was announced on several occasions that an expansion of Britain's atomic power programme was likely to be revealed in the near future. This was presumably delayed by the political situation, but now that the new Minister of Power, Sir Percy Mills, has taken office, it seems probable that a prompt announcement will be made.

Lord Citrine, chairman of the Central Electricity Authority, at a ceremony marking the beginning of construction on the Bradwell site, said that the original nuclear power programme, which provided for a generating capacity of some 2,000 MW by 1965, might be doubled, perhaps even trebled. This would not involve the construction of many more stations than the 12 proposed in the 1955 White Paper, since technical developments had made possible a considerable increase in output per reactor. The progress already made can be gathered from the gain in output achieved by the first C.E.A. stations (each rated at about 300 MW) over Calder A, which has a capacity of some 90 MW. The Bradwell station, which is being built by the Nuclear Power Plant Company and is due for completion by the winter of 1960, will have a total capacity of 390 MW; the figure of 300 MW quoted when the announcement was first made was the guaranteed rating, and a similar conservatism applies to the figures given by the other groups, though the Berkeley station will in fact be smaller than the Bradwell and South of Scotland installations.

Lord Citrine also observed that Britain would need fuel equivalent to 70 million tons of coal a year by 1965. The National Coal Board will be capable of providing only 53 million tons of coal by that date. If the 17 million tons difference is to be provided entirely by nuclear power, some 18 to 20 stations will be required.

Unconfirmed figures published in the daily Press last week suggest that the White Paper figure of 12 stations by 1965 may be raised to 16 or 19 and the total generating capacity to 6,000 or 7,500 MW. By 1975, the electrical capacity may be as high as 40,000 or 65,000 MW. It should be emphasised that the Central Electricity Authority do not confirm these estimates, and in the immediate future, the shortage of steel plate for pressure vessels and heat exchangers and the problem of training sufficient men may impose a limitation. That Sir Percy is also responsible for the steel industry is important in this connection. The electrical manufacturers, however, are confident that they can meet any reasonable demands made on them. In any case some increase in capacity may be expected from the increases in reactor heat output arising from the use of higher temperatures. A representative of the A.E.I.-John Thompson Nuclear Energy Company, Limited, has stated that work on beryllium cans for fuel elements is already in progress with this in view.

Lord Chandos, the chairman of A.E.I., speaking on the eve of a visit to Canada and the United States, has said that the time was not yet ripe for a decision by the Northern Ireland authorities to undertake a nuclear power project, because there were certain base-load problems, but nuclear power would for Northern Ireland represent a saving both in coal and freight. The Welsh authorities are seeking a station, and Cambeltown is approaching the North of Scotland Hydro-Electric Board to begin provisional negotiations for a second Scottish station, this time to be built in Kintyre.

Group's Construction Capacity

By 1958, A.E.I.-John Thompson would be capable of building one station of 300 to 400 MW with two reactors per year, and by 1959, this might be increased by 50 per cent. If it were decided to build all nuclear stations from now on, industry, he considered, was capable of fulfilling the demands made on it. The Berkeley station, which A.E.I.-John Thompson were building in Gloucestershire would be completed in three years; the reason for this speed (an orthodox station may take four years) was the detailed character of the advance planning. Only for part of the construction period, however, would there be night-shift working. No figure has been given for the estimated cost of power from the Berkeley station, but it is believed to be a very little in excess of 0·6*d.* per kWh, taking into account a credit of one-quarter the original fuel cost for plutonium.

Machining Moderator Graphite

The A.E.I.-John Thompson Nuclear Energy Company, Limited, and the Morgan Crucible Company, Limited, Battersea Church-road, London, S.W.11, are forming a joint company, Nuclear Graphite Limited, to specialise in the machining of graphite blocks for reactor moderators. These blocks are often intricate in shape and must be cut to close dimensional limits. Machining capacity will be available to cover any likely expansion in the British nuclear power programme and all overseas orders, and a site for a new plant is being prepared. High-purity graphite will be provided by the United Kingdom Atomic Energy Authority, and made by British Acheson Electrodes Limited.

The Morgan Crucible Company have long experience in the fabrication of graphite and have just completed the manufacture and machining of the special graphite blocks to be employed as the neutron shield for the Dounreay fast breeder reactor. The Morgan Crucible Company is engaged in the development and manufacture of many special materials and components for use in the atomic field, and other associated firms are supplying a variety of products. For example, Morganite Resistors Limited of Jarrow (a subsidiary company) is providing components for electronic and control equipment, while another subsidiary, Morgan Refractories Limited of Neston, Cheshire, is engaged in making and developing a range of special refractory materials.

More on Berkeley

Further technical details concerning the Berkeley nuclear power station have been released by the A.E.I.-John Thompson Nuclear Energy Company, who are responsible for its construction. (Previous references have appeared in ENGINEERING on December 21 and 28, 1956, pages 793 and 828.) The site layout is shown in Fig. 1. Work commenced on January 7.

Station Exports

According to Lord Chandos, his group would be capable of coping both with the United Kingdom Programme and with nuclear power station exports. He thought that gas-cooled reactors with electrical ratings of 75 MW and above offered most scope for export, though smaller gas-cooled reactors with some enrichment might be undertaken. (40 to 60 MW was about the lowest practicable rating without enrichment.) The group would be prepared to carry out any part of an export order from the design and construction of a complete station to supplying single components.

A leading purpose of Lord Chandos's visit to Canada is to draw attention to the experience being accumulated by the A.E.I.-John Thompson Nuclear Energy Company in the construction of gas-cooled graphite-moderated reactors, and to indicate their willingness to undertake export orders for reactor plant. The group is prepared to design and supervise building of a station or stations for Canada's nuclear power programme due to come into operation in 1964. In addition to large and small nuclear power stations, the group is prepared to export research reactors, or to sign agreements for the exchange of information.

Britain seems likely to be awarded her first power-reactor export contract in the near future. Mr. Ichiro Ishikawa, leader of the mission sent here last autumn, has recommended to the Japanese atomic energy commission the purchase of a Calder Hall B type of nuclear power station. Since there is necessarily a certain risk involved, he has proposed ordering one station rated at between 100 MW and 150 MW, with the possibility of buying another later. The main point in favour of a British gas-cooled reactor is its use of natural-uranium fuel, which is more readily available than enriched fuels, though the small core of an enriched-fuel reactor might be less subject to damage in the event of an earthquake. Probably the deciding factor will be the experience already gained on the construction of Calder Works and now being accumulated by the firms building the C.E.A. stations. Last year the United Kingdom Atomic Energy Authority tentatively proposed to the Japanese mission the sale of two power reactors of 140 MW, each costing about £37 million, with an additional £10 million for fuel, and delivery in about 4 years. The Westinghouse Corporation made an offer to sell Japan a pressurised water reactor of the same capacity in about four years for £12½ million. The estimate of 500 MW for Japan's requirement of energy from nuclear sources by 1960 is now thought to have been doubled. A general survey of atomic energy in Japan appeared in ENGINEERING on January 4, page 28.

FUSION FURTHERMORE

The prominence we gave two weeks ago to the cold fusion process should not be taken to mean that the production of power from the fusion of hydrogen atoms is already in sight. As we stated, the experiments were only on a laboratory scale, the catalyst was too short lived to give a useful power output, and the existence of a more suitable catalyst had yet to be confirmed. Even if such a catalyst were discovered, the process might still have an unfavourable energy balance; and in any case extensive development problems would remain to be solved. Nevertheless, there are superficial reasons at least for optimism (see Plain Words). Indeed, neither hot nor cold fusion as they are at present understood may be the answer, but some technique based on entirely new concepts of nuclear physics now being evolved.

Cold Comfort

The emergence of an approach to the fusion process in which ultra-high temperatures are not required is bound to appear significant to the engineer, who associates high temperature with insulation and materials problems. Heat losses, for example, tend to be substantial where there are high differential temperatures between a machine and its surroundings. Admittedly, the engineer prefers his heat to be delivered at high temperatures, but temperatures of several million deg. C. are rather beyond his experience.

In our account of the cold or catalysed fusion experiments in California we omitted to mention that the negative μ meson was found to have a preference for deuterium as against hydrogen. (The negative μ meson replaces the orbital electron in the atom, which thereby becomes considerably reduced in size. Thus, whereas a normal deuterium-hydrogen molecule is held together by the weak binding effect of electrons, the mesic molecule is "squeezed" together by the much tighter meason orbit. Once a molecule has formed, there is considerable probability that the two nuclei will fuse.)

Unfortunately the short-lived character of the meson makes it an unsatisfactory catalyst, since

more energy would be required to produce it than would be evolved in the very few fusion reactions it catalysed. The existence of a more suitable particle has yet to be confirmed. In any case the particle accelerator may be an inconvenient or uneconomic source of catalytic particles for a commercial fusion power reactor. (Mesons are produced by the collision with other nuclei of protons accelerated to energies in excess of 300 MeV). Cosmic rays, except at great heights, are unlikely to provide a sufficient number of catalytic mesons, though it might be interesting to send a flask of liquid deuterium and hydrogen up in a high-altitude balloon. The neutrons evolved in a fission reaction are emitted at energies too low (about 6 MeV) to generate mesons by bombardment, and the random neutron energies cannot be organised (except by a gravitational field), since the neutron carries no charge. The problems to be solved before a practical cold fusion reaction can be devised are thus considerable.

Hot Fusion

Considerable progress has already been made in the investigation of thermonuclear fusion, and we summarise in later sections a number of recently published theoretical papers dealing with the pulsed-discharge approach to this process. (High electric currents provide both the heating effect and the magnetic field used to contain the high-temperature gas plasma.) The conditions proposed in one paper for a power-producing thermonuclear reactor are stated to be within reasonable engineering limits. Elsewhere (*Modern Power and Engineering*, December, 1956) it has been suggested that the chamber for a thermonuclear reactor might be made to rotate about a vertical axis so that the containing walls would be protected by a shield of liquid, held in position by centrifugal action. In any case, the high temperatures involved need not present a serious difficulty if the reacting volume is small and contained by a magnetic field, since the total heat output can then be limited to a reasonable value. But whether or not thermonuclear fusion can be controlled to produce electric power, it will almost certainly provide a means of generating valuable neutrons.

Papers on Fusion Studies

The character of thermonuclear reactions, the conditions in which they may occur, and other associated problems are discussed in *The Proceedings of the Physical Society*, Section B (vol. 70, part 1, January 1, 1957) published this week. The *Proceedings* include six papers by members of the Atomic Energy Research Establishment dealing with thermonuclear subjects; and some general points taken from their contents are summarised below.

Criteria for Thermonuclear Reactions

It has been widely conjectured that some form of controlled thermonuclear reactor, capable of producing a useful amount of power, will some day be constructed. In a paper entitled "Some Criteria for a Power Producing Thermonuclear Reactor" (J. D. Lawson) the power balance in such a reactor is considered, and some criteria which have to be satisfied in a power-producing system are derived. Two classes of reactor are considered: first, self-sustaining systems in which the charged reaction products are trapped, and second, pulsed systems in which all the reaction products escape so that energy must be supplied continuously during the pulse. It is found that not only must the temperature be sufficiently high, but also the reaction must be sustained long enough for a definite fraction of the fuel to be burnt, since the organised energy used to heat the gas is ultimately degraded to the temperature of the walls of the apparatus, so that the resulting losses must be compensated. The criteria given are necessary, though by no means sufficient for the successful operation of a thermonuclear reactor.

Of the exoergic reactions involving light nuclei, those between the hydrogen isotopes (the so-called D-D and T-D reactions) are by far the most probable at low energies. Of these the T-D (tritium-deuterium) reaction has the higher cross section, but since tritium does not occur naturally, it is necessary to use a system in which it can be bred. This may be done by capturing the neutrons emitted in the T-D reaction in lithium 6 (^{6}Li), which then decays into tritium (hydrogen 3) and helium 4 (^{4}He). An expression for the energy released per unit time and volume by thermonuclear reactions in a hot gas is given:

$$P_R = n_1 n_2 [v\sigma(T)] E$$

where n_1 and n_2 are the number densities of the nuclei of the first and second kinds, and $[v\sigma(T)]$ is the product of the relative velocities of the nuclei and the reaction cross section averaged over the Maxwellian velocity distribution corresponding to a temperature T, and E is the energy released by one reaction. If the ions are of the same kind (as in the D-D reaction) $n_1 n_2$ is replaced by $2(n/2)^2 = \frac{1}{2}n^2$.

Energy can be lost from the hot gas in two ways, by radiation and by conduction. At temperatures above about 10^6 deg. hydrogen is completely ionised and radiation occurs principally as *bremsstrahlung* (free-free transitions). The mean free path of such radiation is large and consequently in a reactor of controllable size virtually all of it would escape. The Stefan-Boltzmann T^4 law does not hold under these circumstances; the variation of intensity with temperature can only be found by a detailed study of the radiation process. The power radiated per unit volume in hydrogen is given by

$$P_B = 1{\cdot}4 \times 10^{-34} n^2 T^{\frac{1}{2}} \text{ watts cm.}^{-3}$$

Conduction loss is difficult to treat in a general way, since it depends on the geometry of the system, its density and temperature distribution, and also the wall material. Here, however, it is optimistically assumed that the conduction loss is zero.

It is of interest to see at what temperature the nuclear power release is equal to the radiated power. This may be called the "critical temperature" and is the hypothetical temperature which would be needed for a self-sustaining system if all the radiation escaped but the reaction products were retained. The critical temperature is about 150 million deg. C. for the D-D reaction (assuming that the tritium is burnt as soon as it is formed, but that the helium 3 is not burnt), and 30 million deg. for the T-D reaction. The critical temperature is a somewhat artificial concept; it does not mean that if a thermonuclear fuel is heated to this temperature a reaction will be set off in the way that a chemical explosion is set off, or that the fuel can be ignited as in a gas jet. This would only be true if the energy of the reaction were deposited close to where it was released, that is, if the range of the reaction products was short compared with the dimensions of the apparatus. In fact, the range of the particles will almost certainly be large compared with the dimensions of the apparatus if the system is to be of controllable size, so that unless the tracks are somehow coiled up it will be the walls of the apparatus which are heated rather than the gas, and energy must be fed continuously to sustain the reaction.

Discussing systems in which the reaction products are retained, the author gives, as an example of the orders of magnitude involved, the slowing down range of the charged reaction products in a gas at 10^8 deg. C. and 10^4 atmospheres pressure ($n = 3 \times 10^{27}$ nuclei per cub. cm.) as of the order of a kilometre. The range of the neutrons is hundreds of kilometres. Considering systems in which the reaction products escape, he states that for a useful D-D reactor T must exceed 2×10^8 deg. and nt must be more than 10^{16} (t is the duration of the reaction). Thus, for a pulse of 1 microsecond duration, n must be greater than 10^{22}; this corresponds to a pressure of 6×10^8 atmospheres at a temperature of 2×10^8 deg. C. Particles move several metres during this time, and the mean free path for momentum transfer is several centimetres even at this high density. These distances are measured along a track which may be spiralled or oscillatory. For a T-D reaction nt must exceed 10^{14} and the minimum temperature is 3×10^7 deg. C. The values for both reactions and both open and closed systems correspond to the burning of about 1 per cent. of the fuel, which would have to be much exceeded in practice.

Reaction Rates

As a preliminary to any study of the feasibility of obtaining power from controlled thermonuclear reactions it is necessary to estimate the rate of production of energy, and hence the reaction rate, as a function of temperature. A paper, "Thermonuclear Reaction Rates" (W. B. Thompson) gives the reaction rates for a number of processes to as high a degree of accuracy as is compatible with present limited knowledge of the low-energy cross sections, and describes the calculation of these rates. It is shown that the thermonuclear reaction rate between two gases in thermal equilibrium and of densities n_1 and n_2 nuclei per unit volume can be written as $n_1 n_2 [\sigma v]$ where $[\sigma v]$ is a suitable average of the product of the reaction cross section and relative velocity, and for any reaction is a function of temperature alone (see previous paper). These functions are given for a number of reactions between light nuclei. The particular reactions considered, all exoergic and all involving deuterium or tritium, are listed in Table I, together with some information about the cross sections and energy release.

Pinched Gas Discharge

As has been suggested, in order to obtain power from thermonuclear reactions of hydrogen isotopes, it is necessary to achieve temperatures in the range 10^7 to 10^9 deg. K., and to do so without dissipating amounts of heat which are large compared with the inescapable radiation losses. One promising method is that of the pinched gas discharge. In a paper called "Equilibrium Characteristics of a Pinched Gas Discharge Cooled by Bremsstrahlung Radiation" (R. S. Pease) the characteristics of a hydrogen discharge in which dissipation of

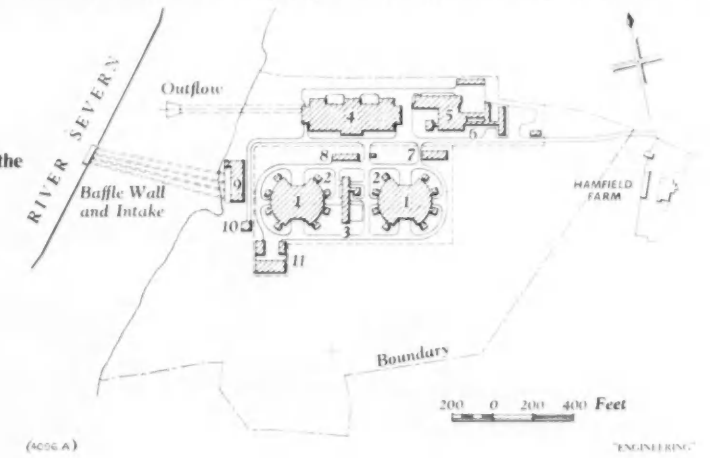


Fig. 1 Site layout of the Berkeley station.

energy is supposed to take place entirely by radiation of *bremsstrahlung*. Standard formulae for the electrical resistance and for the radiating properties of a fully ionised gas have been combined with pinch-effect relations to obtain the stationary-state radial-distribution functions and current-voltage characteristics of a radiation-cooled discharge, using a simplified model in which a stationary, axially symmetrical discharge is generated in a long straight tube. The calculations are applied to the requirements of a power-producing thermonuclear reactor. The chief results are that in a stationary state a pinched discharge will exist with radiation cooling, that the magnitudes of the voltages, tube diameters and initial gas pressure are within reasonable engineering limits, and that a maximum current of one two-million amperes will be encountered. Instabilities which may invalidate some of the assumptions made are discussed in other papers: "Hydromagnetic Instabilities of an Ideally Conducting Fluid" (R. J. Taylor) and "Observations of the Instability of Constricted Gaseous Discharges" (R. Carruthers and P. A. Davenport). Examination of gaseous discharges in both straight and toroidal discharge tubes carried out by the authors of the second paper have shown that a constricted current channel becomes unstable at a particular value of current. Discharges have been studied with currents up to 1,500 A, and high-speed photographs show the helical form of these unstable current channels.

Further discussion of the gas-discharge approach to thermonuclear fusion appears in a paper "An Elementary Theory of the Transient Pinched Discharge" (J. E. Allen). Experiments have shown that if a high current is rapidly established in a low-pressure gas discharge, the plasma is accelerated towards the discharge axis by the self-magnetic "pinch" force. This magnetic pinch force results from the interaction of the discharge current with its own magnetic field. The present paper refers to the case where shock waves are set up in the gas.

It is assumed, for simplicity, that the discharge consists of a large slab of completely ionised gas (as shown in Fig. 2), in which the following conditions exist: (*a*) the electrical conductivity is infinite, (*b*) the current rises instantaneously from zero to a finite value and then remains constant, and (*c*) the thickness of the shock wave is small compared with the dimensions of the discharge chamber. It follows from the first condition that only the energy delivered to the gas via electromechanical forces is considered in the theory; the energy dissipation associated with Joule heating is neglected. Another result which follows directly from the first condition is that the current flows only on the surface of the discharge, owing to the skin effect, and the self-magnetic field does not penetrate the plasma. The pinch force acting per unit area of the current sheet due to the interaction with its own magnetic field is constant if the current remains constant, and it is assumed, for simplicity, that the walls of the discharge chamber constitute the return current path (see Fig. 2). Hence the discharge inductance is zero, initially, so that conditions (*a*) and (*b*) are self-consistent. It is shown that one-half of the supplied energy is stored in the magnetic field and the other half is delivered to the gas via the electromechanical force. This result applies to all constant current systems.

In the idealised case under consideration, a constant force drives the current sheet towards the centre of the discharge. A shock wave precedes the current sheet in the same way that a shock wave travels ahead of a piston which is plunged into a tube. The resulting sequence of events is illustrated in detail in the distance-time diagram, Fig. 3. The inward-moving shock wave does two things: it sets the gas in motion, and it increases the temperature of the gas. Thus the energy which is delivered to the gas by the electromechanical force is partly associated with directed motion and partly with random (thermal) motion; in the limiting case of a strong shock, in a monatomic gas, the energy is equally divided between these. Formulae for the Mach number of the shock wave, the shock velocity, the density ratio and the temperature ratio are given in the paper for the case of a monatomic gas.

TABLE I

Reaction	(1)	(2)	(3)
$^2H(d, p)^3He$	4·03	0·079	1
$^2H(d, n)^3He$	3·25	0·09	1
$^3H(d, n)^4He$	17·58	5·0	0·1
$^3He(d, p)^4He$	18·34	0·8	0·45
$^3H(t, 2n)^4He$	11·32	0·098	1
$^6Li(d, p)^7Li$	5·02	0·01	1
$^6Li(d, n)^7Be$	3·37	0·016	1
$^6Li(d, n)^6He + ^3He$	1·79 total		
$^6Li(d, \alpha)^4He$	22·36	0·026	0·6
$^7Li(d, n)^8Be$	15·01	0·045	1
$^7Li(d, n)2^4He$	15·1	—	—

(1) Energy released (MeV).
(2) Maximum cross sections below 1 MeV (barns)—maximum probability of reaction occurring at energies lower than 1 MeV.
(3) Bombarding energy for maximum cross section (MeV)—bombarding energy at which reaction most likely to occur.

Proton Form

Two weeks ago we published a report that the proton resembled a peach, with soft exterior and hard core. This was of course a major simplification, and particles are not, of course, regarded by physicists as simple entities of this kind. We therefore give here a more detailed explanation of the experiment to which we referred. The structure and size of the proton have been studied by means of high-energy electron scattering at energies of 200, 300, 400, 500 and 550 MeV and angles ranging from 30 to 135 deg. (E. E. Chamber and R. Hofstadter, *Physical Review*, vol. 103, No. 5, September 1, 1956). The magnitude and variation with angle of the deviations observed determine a structure factor for the proton, and thereby give the size and shape of the charge and magnetic-moment distributions within the proton. An interpretation, consistent at all energies and angles and agreeing with the authors' earlier results, fixes the r.m.s. radius at $(0{\cdot}77 \pm 0{\cdot}10) \times 10^{-13}$ cm. for each of the charge and moment distributions. The shape of the density function is not far from a Gaussian with r.m.s. radius $0{\cdot}70 \times 10^{-13}$ cm. or an exponential with r.m.s. radius $0{\cdot}80 \times 10^{-13}$ cm.

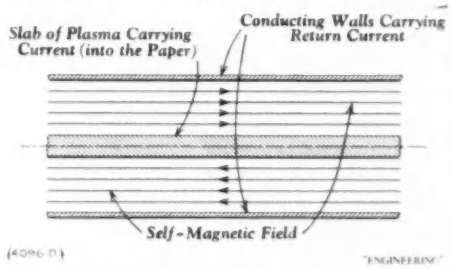


Fig. 2 Self-magnetic field associated with a conducting slab of gas. A thermonuclear reaction may be contained by such a magnetic field so that the reactor chamber is protected from the high temperatures involved.

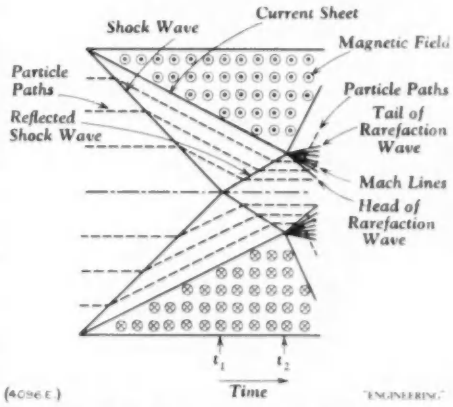


Fig. 3 Distance time diagram illustrating the sequence of events in a pinched gas discharge, showing shock wave formation.

GENERAL NEWS

Ships and Submarines

Britain is to build a large reactor-powered tanker. Speaking in Paris at a course on atomic energy management, Sir John Cockcroft said that the tanker would be larger than the Queen Mary (with a displacement of more than 80,000 tons) and would probably serve to carry oil round the Cape route.

The new tanker would be capable of 25 to 30 knots. Sir John said that it was not known whether atomic propulsion of tankers would be an economic proposition; running costs for the United States atomic-powered submarine were about six times those for commercial shipping, and the proposed United States £15 million 12,000 ton passenger-cargo ship was not intended to be economical. The application of nuclear energy to marine propulsion was discussed last year at a closed conference organised by A.E.R.E. and the British Shipbuilding Research Association. It was opened by Sir John Cockcroft, and attended by 49 shipowners, 58 shipbuilders and representatives of several Government departments. Efforts to develop nuclear means of propelling merchant ships was said to be worth pursuing actively, but a large gap in costs had to be bridged before such methods became commercially attractive. Reactor systems based on an organic liquid moderator and on natural uranium fuel were under consideration, and schematic designs for installations, including turbine plant, were being prepared.

Britain's first nuclear-propelled submarine is in an advanced stage of design according to Admiral of the Fleet Earl Mountbatten, the First Sea Lord. It would, he said at the Navy League's diamond jubilee fund dinner, have been at a later stage had the Government not decided to concentrate on nuclear power development. A dramatic name for the vessel is now being sought.

Last week we quoted a report that the United States atomic-powered submarine had been refuelled. This was somewhat in advance of the facts, for Nautilus, which has now travelled more than 55,000 miles on her first charge of enriched fuel, is in fact to be refuelled next spring, the United States Navy announced last week. The vessel will at the same time undergo its first complete overhaul, and the original reactor core will be sent to the Atomic Energy Commission's reactor testing station at Arco, Idaho, for examination and reclamation of unused fuel. Nautilus was first reported under way on nuclear power on January 17, 1955.

The United States authorities have not yet decided what to do with the 3,260 ton submarine Seawolf, which some time ago developed leaks in the steam superheater system, according to the *New York Herald-Tribune*. The leakage presumably arose from corrosion by the liquid-sodium reactor coolant. If the decision were taken to seal off the superheater section the power plant would lose 20 per cent. of its output, but if another reactor is fitted costs and delays would be very serious. Latest reports state that Seawolf has now put to sea for the first time.

Reactors for Heating

A one-day conference on the utilisation of heat from nuclear reactors was held at the Atomic Energy Research Establishment, Harwell, on January 18. Potential uses for the heat produced in reactors, apart from the generation of electricity, were discussed. Among those attending the conference, to which attendance was limited in order to keep the discussions informal, were representatives from interested Government departments, research establishments, research associations and the chemical industry. The conference was opened by Sir John Cockcroft, and papers were presented on: "U.K.A.E.A. Reactor Developments" (Dr. J. V. Dunworth, A.E.R.E., Harwell); "The Use of Heat on a National Scale" (Sir Sidney Frew, Ministry of Fuel and Power); "Heat Use in the Heavy

Chemical Industry" (G. Nonhebel, Imperial Chemical Industries, Limited); "Some Thoughts on the Use of Heat from Nuclear Reactors" (C. M. Nicholls, A.E.R.E., Harwell); "Heat Interests of the Gas Council" (Sir Charles Ellis, Gas Council); "Heat Interests of the National Coal Board" (Dr. W. Idris-Jones, National Coal Board); and "Large Scale Distillation of Water" (J. Leicester, British Launderers' Research Association).

Indian Establishment Inaugurated

The Indian Atomic Energy Establishment was inaugurated by the Prime Minister of India, Mr. Pandit Nehru, on January 20. On the same occasion the swimming-pool research reactor to which we referred in Atomic Review last week was formally opened. Our report gave its cost as Rs.27½ million, but though taken from a published source and checked with the Indian High Commission Press Office, this figure may be incorrect. Elsewhere, an estimate of £200,000 has been suggested, which is closer to the cost of our own similar reactor, LIDO.

Uranium Supplies

In December, 1956, the United Kingdom Atomic Energy Authority announced a relaxation of restrictions on the release of atomic information and this has been followed by publication of output and reserves of many of the South African uranium producers. The output figures relate only to production since July 1, 1955, but when complete for all producers will permit a much more accurate assessment of the world supply position. On the basis of figures already published, total South African production has been estimated at about 4,500 tons of uranium oxide, which is equivalent to 3,285 tons of uranium per annum. This is about equal to United States production in 1956 and these two countries together probably accounted for rather over half the total world production, excluding the Russian bloc.

During 1957 Canada is expected to surpass both the United States and South Africa and to produce about 4,000 tons of uranium metal. By mid-1958 Canadian mill capacity is expected to be sufficient for an output of 12,500 tons, which is about equal to total Free World production in 1956. Australia and South America are also expected to make important contributions.

The future pattern of world production is likely to depend largely on the trend of consumption and the level of prices, since the stage is already past in which an actual physical shortage of potential supplies was envisaged. It is already apparent that at any rate for some years it will not be necessary to develop inaccessible deposits and that production is likely to be concentrated in the hands of the lower-cost producers. Estimates of future demand are, of course, very tentative and are largely dependent on strategic considerations; and it should not be overlooked that techniques of power generation based on nuclear energy but not dependent on uranium are, at least, a long-term possibility. It has, however, been estimated for the Free World that present military requirements are probably between 10,000 and 15,000 tons of uranium metal per annum, while demand for generating purposes may amount to 10,000 tons per annum in 20 years. In view of the stepping-up of the atomic energy programme in this country the latter figure may well be reached earlier, since a single nuclear power station such as that to be built at Hunterston will require a recurring charge of 500 tons of uranium metal once every three years. Nevertheless, on present indications it would appear that production is likely to expand faster than consumption in the immediate future and that Free World production by 1959 may well be of the order of 25,000 tons.

B.N.E.C. Admits Metal Institutes

At a meeting of the board of the British Nuclear Energy Conference, under the chairmanship of Sir John Cockcroft, it was decided on January 9, 1957, to admit to membership the Iron and Steel Institute, and the Institute of Metals.

NOTICES OF MEETINGS

Aslib

LONDON
"Communication of Science by Means of Film," by Dr. A. R. Michaelis. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Wed., Jan. 30, 6 p.m.*

Association of Supervising Electrical Engineers

HOVE
Discussion on "Valves." Brighton and Hove Branch. New Imperial Hotel, First-avenue, Hove. Wed., Jan. 30, 7.30 p.m.
LIVERPOOL
"X-Ray Production and Problems," by L. C. Maple. Liverpool Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Fri., Feb. 1, 7.30 p.m.

British Institution of Radio Engineers

LONDON
Papers on "Battery-Operated Equipment." London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Jan. 30, 6.30 p.m.*

British Interplanetary Society

LONDON
"Accelerations in Flight," by Wing Commander F. Latham. Caxton Hall, off Victoria-street, S.W.1. Sat., Feb. 2, 6 p.m.

Building Centre

LONDON
Film "Fawley Achievement," exhibited by Esso Petroleum Co. Ltd. Wed., Jan. 30, 12.45 p.m.

Chemical Society

BELFAST
"Paint Research: Electron Microscopy and Related Techniques," by T. R. Bullett. Northern Ireland Branch. Queen's University, Belfast. Mon., Jan. 28, 7.15 p.m.
SOUTHAMPTON
"Nuclear Magnetic Resonance Techniques," by Dr. R. Richards. Southampton Branch. Chemistry Department, The University, Southampton. Fri., Feb. 1, 5 p.m.

Diesel Engineers and Users Association

LONDON
Discussion on *draft for comment* "B.S. 649—Internal Combustion Engines for Stationary Purposes," to be opened by the President, K. H. Tuson. Caxton Hall, off Victoria-street, S.W.1. Tues., Jan. 29, 2.30 p.m.

Illuminating Engineering Society

BATH
Discussion on architectural subjects. Bath and Bristol Centre. Offices of the South Western Electricity Board, Bath. Fri., Feb. 1, 7 p.m.
LEEDS
"Lighting Installation Practice in Mines," by W. B. Bell. Leeds Centre. E.L.M.A. Lighting Service Bureau, 24 Aire-street, Leeds, 1. Mon., Jan. 28, 6.15 p.m.
LEICESTER
Brains Trust Meeting. Leicester Centre. Demonstration Theatre, East Midlands Electricity Board, Charles-street, Leicester. Mon., Jan. 28, 6 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Fire Prevention," by G. F. Goodman. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Mon., Jan. 28, 7.30 p.m.
LEEDS
"Civil Engineering," by Professor R. H. Evans. West and East Yorkshire Branch. The University, Leeds. Mon., Jan. 28, 7.30 p.m.
SHEFFIELD
Discussion on "The Care and Maintenance of Wire Ropes." Sheffield Branch. Grand Hotel, Sheffield. Thurs., Jan. 31, 7.30 p.m.

Institute of Marine Engineers

LIVERPOOL
"Modern Marine Steam Turbines," by J. H. Gooch. Junior Lecture. Merseyside and North Western Section. Old Swan Technical College, Liverpool. Mon., Jan. 28, 7.30 p.m.

Institute of Metals

BIRMINGHAM
"Pure Metals," by Dr. J. C. Chaston. Birmingham Local Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Jan. 31, 6.30 p.m.

Institution of Chemical Engineers

BIRMINGHAM
Annual General Meeting at 2.30 p.m.; and "Automatic Control of Continuous Distillation Plant," by E. J. Eaton and R. Parkins, at 3 p.m. Midlands Branch. Midlands Institute, Paradise-street, Birmingham. Sat., Feb. 2.

Institution of Civil Engineers

LONDON
"The Campaign for Cleaner Rivers," by M. Lovett. Public Health Division. Tues., Jan. 29, 5.30 p.m.*
"Large-Span Prestressed-Concrete Bridges Constructed by the Freyssinet System," by Y. Guyon. Structural and Building Division. Tues., Feb. 5, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"An Experimental Study of High Permeability Nickel-Iron Alloys," by C. E. Richards, E. V. Walker and A. C. Lynch; "A Method for the Precise Measurement of Permittivity of Sheet Specimens," by A. C. Lynch; "A Bridge Network for the Precise Measurement of Direct Capacitance," by A. C. Lynch; and "A Simple Transformer Bridge for the Measurement of Transistor Characteristics," by W. F. Lovering and D. B. Britten. Measurement and Control Section. Tues., Jan. 29, 5.30 p.m.*
"Power System Protection, with Particular Reference to the Application of Junction Transistors to Distance Relays," by C. Adamson and L. M. Wedepohl; and "A Dual-Comparator Mho-Type Distance Relay Utilising Transistors," by C. Adamson and L. M. Wedepohl. Supply and Measurement Sections. Wed., Jan. 30, 5.30 p.m.*
NEWCASTLE-UPON-TYNE
"Some Aspects of Heat-Pump Operation in Great Britain, with Particular Reference to the Shinfield Installation," by Miriam V. Griffith. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Jan. 28, 6.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"The Education and Training of Technologists," by Sir David S. Anderson; and "The Education and Training of Technicians and Craftsmen in the Shipbuilding and Engineering Industries," by Dr. W. S. Cormack. Tues., Jan. 29, 6.30 p.m.*

Institution of Highway Engineers

MIDDLESBROUGH
"Modern Concrete Road Construction," by D. R. Sharp. Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. Fri., Feb. 1, 7 p.m.

Institution of Locomotive Engineers

MANCHESTER
"Carriage Warming," by F. J. Pepper. Manchester Centre. College of Technology, Manchester. Wed., Jan. 30, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Economy in Commercial-Vehicle Operation." Automobile Division. Wed., Jan. 30, 6.45 p.m.*
Discussion on "Locking Devices and the Prevention of Loosening of Components." Applied Mechanics Group. Tues., Feb. 5, 6.45 p.m.*
BASINGSTOKE
"Overdrives," by S. H. Ashby. Southern Branch. Canteen, Transport Equipment (Thornycroft), Ltd., Basingstoke. Wed., Jan. 30, 7.30 p.m.
BRISTOL
"Servicing of Injectors," by R. Lewes; "The End of a Piston's Life," by A. C. Whitehorn; "Brakes," by J. G. Remington. Western A.D. Centre. Royal Hotel, Bristol. Thurs., Jan. 31, 6.45 p.m.
DERBY
"Quality in Engineering," by F. Nixon. Joint meeting of Derby A.D. Centre and the East Midlands Branch. Welfare Hall, Rolls-Royce Ltd., Nightingale-road, Derby. Mon., Jan. 28, 6.15 p.m.
MANCHESTER
"Computer-Controlled Machine Tools," by H. Ogden. North Western Industrial Administration and Engineering Production Group. Engineers' Club, Albert-square, Manchester. Thurs., Jan. 31, 6.45 p.m.

Institution of Production Engineers

BRISTOL
"Production Engineering in the Coal Industry," by Dr. L. C.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Aslib (Association of Special Libraries and Information Bureaux), 4 Palace-gate, London, W.8. (WEStern 6321.)
Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (TATe Gallery 9371.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Diesel Engineers and Users Association, 19 Old Queen-street, London, S.W.1. (TRAfalgar 5597.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Public Health Engineers, 118 Victoria-street, London, S.W.1. (VICtoria 3017.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
King's College (University of London), Strand, London, W.C.2. (TEMple Bar 5454.)
Manchester Metallurgical Society, The Kennedy Press, Ltd., 31 King-street West, Manchester 3.
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Scientific Film Association, 164 Shaftesbury-avenue, London, W.1. (TEMple Bar 4694.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

Tyte. Western Section. University Engineering Laboratories, University-walk, Bristol 8. Wed., Jan. 30, 7.15 p.m.
CHESTER
"Automatic Inspection: The Anatomy of Conscious Machines," by John Sargrove. Liverpool Section. Grosvenor Hotel, Chester. Wed., Jan. 30, 7.30 p.m.
LINCOLN
"Valid Incentives," by E. C. Gordon England. Lincoln Section. Ruston Club, Lincoln. Thurs., Jan. 31, 7.30 p.m.
OXFORD
"The Use of Rubber in Engineering," by Dr. A. N. Gent. Oxford Section. Town Hall, Oxford. Tues., Jan. 29, 7.30 p.m.
SHREWSBURY
"Influence of Production Problems on Modern Machine-Tool Design," by C. A. Sparkes. Shrewsbury Section. Technical College, Shrewsbury. Wed., Jan. 30, 7.30 p.m.
SOUTHAMPTON
"Atomic Energy for Aircraft Propulsion," by J. E. Perkins. Southern Section. The University, Southampton. Wed., Jan. 30, 7.15 p.m.

Institution of Public Health Engineers

LONDON
Discussion on "Automatic Control in Sewage Works." Denison House, 296 Vauxhall Bridge-road, S.W.1. Mon., Jan. 28, 6 p.m.

Institution of the Rubber Industry

MANCHESTER
"Butadiene and Its Copolymers," by Maldwyn Jones and N. D. MacLeod. Manchester Section. Grand Hotel, Manchester. Mon., Jan. 28, 6.45 p.m.

Institution of Structural Engineers

BIRMINGHAM
"Erection Procedure, with Special Reference to Erectors' Problems," by A. G. Osborne. Midland Counties Graduates' and Students' Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Fri., Feb. 1, 6.30 p.m.
BRISTOL
Open Meeting. Western Counties Branch. New Engineeering School, The University, Bristol. Fri., Feb. 1, 6 p.m.
PLYMOUTH
Films on bridging and welding. South Western Counties Branch. Duke of Cornwall Hotel, Plymouth. Fri., Feb. 1, 7 p.m.

Junior Institution of Engineers

LONDON
"Trans-Ocean Deep-Sea Submerged Repeater Systems," by E. F. S. Clarke. Fri., Feb. 1, 7 p.m.*
BIRMINGHAM
Film Evening. Midland Section. James Watt Memorial Institute, Birmingham. Wed., Feb. 6, 7 p.m.

King's College, London

LONDON
"Undergraduate and Post-Graduate Education of Engineers in European Countries," by Professor S. J. Davies. Public Lecture. Mon., Feb. 4, 5.30 p.m.

Manchester Metallurgical Society

MANCHESTER
"The Preparation of Germanium and Silicon for Use in Semi-Conductor Devices," by S. E. Bradshaw. Central Library, Manchester. Wed., Jan. 30, 6.30 p.m.

Reinforced Concrete Association

GLASGOW
"Applications of Prestressed Concrete," by E. H. Cooley. Scottish Branch. St. Enoch Hotel, Glasgow. Mon., Jan. 28, 6.30 p.m.*
LIVERPOOL
"Load Factor Design of Reinforced-Concrete Buildings," by Dr. D. D. Matthews. North Western Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Wed., Feb. 6, 6.30 p.m.*
MANCHESTER
"Load Factor Design of Reinforced-Concrete Buildings," by Dr. D. D. Matthews. College of Technology, Sackville-street, Manchester. Tues., Feb. 5, 6.45 p.m.*

Royal Aeronautical Society

LONDON
"Design for Production," by E. D. Keen. Section Lecture. Tues., Jan. 29, 7 p.m.
AYLESBURY
"Synthetic Training Methods in Aviation," by W. Makinson. Halton Branch. Canteen, Air Trainers Ltd., Aylesbury, Bucks. Thurs., Feb. 7, 6.30 p.m.

Royal Society of Arts

LONDON
"Mining Education and Training," by I. C. F. Statham. Cadman Memorial Lecture. Wed., Feb. 6, 2.30 p.m.

Royal Statistical Society

LEICESTER
"American Approach to Quality Control," by C. S. Smith. Leicester Group. Leicester College of Technology, The Newarke, Leicester. Thurs., Jan. 31, 7 p.m.

Scientific Film Association

LONDON
"Films and Automation," by S. B. Bailey. Mezzanine Cinema, Shell-Mex House, Strand, W.C.2. Fri., Feb. 22, 6.30 p.m. (Admission by ticket, for which early application is recommended.)

Sheffield Metallurgical Association

SHEFFIELD
Open Meeting. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Jan. 29, 7 p.m.

Society of Instrument Technology

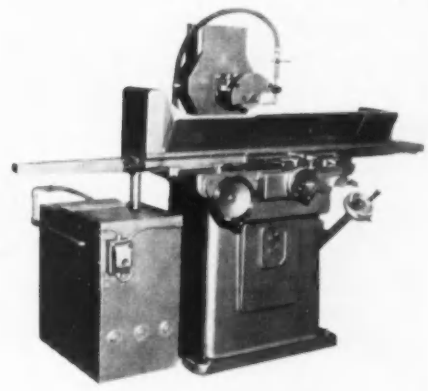
LONDON
"The Development of Instruments for Measuring the Performance of Steam Locomotives with the Mobile Testing Plant," by Dr. H. I. Andrews. Manson House, 26 Portland-place, W.1. Tues., Jan. 29, 7 p.m.*
CHESTER
"Automatic Inspection: the Antomy of Conscious Machines," by John A. Sargrove. Chester Section. 5 King's Buildings, King-street, Chester. Wed., Jan. 30, 7 p.m.
FAWLEY
"Electrical Capacities as a Means of Industrial Measurement," by A. Green. Fawley Section. Copthorne House, Fawley, Hants. Fri., Feb. 1, 7 p.m.

Women's Engineering Society

LONDON
"Direct Use of Solar Energy," by Dr. Harold Heywood. 45 Great Peter-street, S.W.1. Wed., Jan 30, 7 p.m.*

TWO NEW GRINDING MACHINES

Two new machines, a surface grinder and a cylindrical grinder, added to the range made by A. A. Jones and Shipman, Limited, Narborough Road South, Leicester, are illustrated herewith.



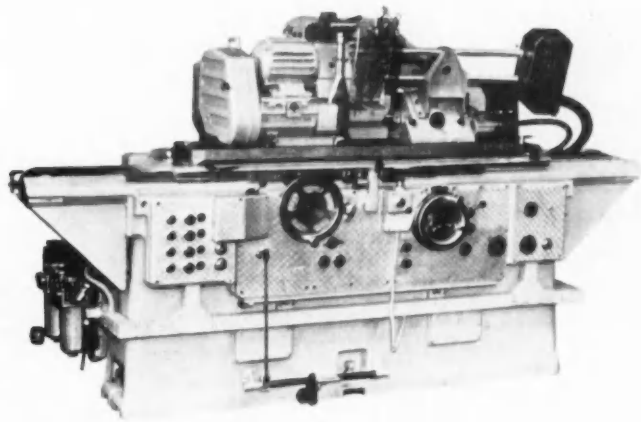
A grinding surface of 24 in. by 8 in. is provided on the Jones-Shipman grinder, which has hydraulic table traverse and feed.

SURFACE GRINDING

A table with a working surface of 24 in. by 8 in. is provided on the hydraulic surface grinder, and the machine is available either as a basic design with hydraulic table and cross-traverse, or in three variants of this basic design. In the first of the variants automatic downfeed is added to the wheelhead. In the second, power rise and fall to the wheelhead are provided, and the third variant has both automatic downfeed and power rise and fall. The wheelhead has a maximum vertical traverse of 11 in., giving a dimension of from $3\frac{1}{4}$ in. to $14\frac{1}{4}$ in. between the wheel spindle centre and the table. The wheel is 8 in. in diameter by $\frac{3}{4}$ in. wide, and runs at 2,450 r.p.m. Table traverse is variable between 10 and 60 ft. per minute, and the cross feed, which is hydraulically operated through a ratchet and pawl, can be varied from 0·007 in. to 0·070 in. per reversal.

PRODUCTION CYLINDRICAL GRINDING

High production rates with accurate size repetition are the characteristics of the cylindrical grinding machine, which will grind work up to 7 in. in diameter by 24 in. long if fitted with a plain tailstock, or up to the same diameter and 27 in. long if the manufacturers' "full-clearance" tailstock is used. The table swivels up to 18 deg. Table traverse rates are variable between 3 in. and 280 in. per minute, and there are six speeds on the workhead, from 40 to 320 r.p.m. The grinding wheel can be run at 1,050 or 1,200 r.p.m.



The Jones-Shipman cylindrical grinder is designed for semi-automatic operation, and will grind work up to 7 in. diameter by 24 in. or 27 in. long, according to the type of tailstock fitted.

The machine is semi-automatic in operation, being equipped with a spark-out timing device, and once it is loaded it can run through its cycle automatically. It is so designed that it can operate in conjunction with gauge-control equipment, the measuring unit being made by Taylor, Taylor and Hobson, Limited, Leicester. A new feature is the provision of "dwell," so arranged that it can be brought in at either end of the stroke (or at both ends), for periods of up to 10 seconds, individually variable. The machine controls can be coupled together by means of switches, both when plunge grinding with a continuous infeed, and when traverse grinding with an intermittent infeed, to give single push-button control of the complete cycle.

FACTORY FOR LOW-HEAT INPUT WELDING ALLOYS

First developed in Switzerland some 50 years ago and subsequently perfected in the United States by the Eutectic Welding Alloys Corporation, New York, the Eutectic low-temperature welding alloys are proprietary low-melting point non-fusion welding filler metals used for maintenance, repair and other forms of welding in engineering works. The Eutectic Welding Alloys Company, Limited, of Great Britain, was founded five years ago and recently a new factory was opened on the North Feltham Trading Estate, Faggs-road, North Feltham, Middlesex. In this factory the firm's welding alloys will be manufactured; they are supplied either as welding rods together with "companion fluxes" or as electrodes having a special "FrigidArc" coating.

At a reception, attended by Mr. A. J. Speakman, deputy director of the British Productivity Council, and held at the Dorchester Hotel, London, W.1, on January 14, on the occasion of the opening of the new factory, Mr. R. D. Wasserman, governing director of the company, and other speakers, emphasised that the firm's welding rods, electrodes, filler metals and ancillary products utilised the phenomenon of surface alloying during the welding process. In this manner, uniform joints having optimum physical properties could be obtained at welding temperatures considerably below the melting points of the metals to be joined. Bonding was thus obtained with very little fusion of the surface of the parent metal and the dangers of warping, distortion and embrittlement were greatly minimised.

Alloys for repairing grey or alloy cast-iron components or for sealing fine cracks and porosities and for building up worn or undersized parts are obtainable. Other alloys for use with "all steels," brass, bronze, copper, nickel and its alloys, aluminium and its alloys, and magnesium alloys, are available, as are also materials for producing hard and abrasion-resisting deposits on metal surfaces.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list, arranged chronologically, appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *November* 30, *page* 702; *or December* 28, *page* 825. *Organisers are invited to send to the Editor particulars of coming events as soon as arrangements are made.*

Stationery Trade Fair.—Mon., Feb. 4, to Fri., Feb. 8, at the Grand and Metropole Hotels, Brighton. Organised by the Stationers' Association of Great Britain and Northern Ireland, 6 Wimpole-street, London, W.1. Tel. LANgham 9256.

Education and Training of Naval Architects and Marine Engineers, Symposium.—Wed., Feb. 6, at 10 Upper Belgrave-street, London, S.W.1. Organised jointly by the Institute of Marine Engineers, 85 The Minories, London, E.C.3 (Tel. ROYal 8493); and the Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. Tel. SLOane 4622.

Hi Fi Electrical and Radio Show.—Wed., Feb. 6, to Sat., Feb. 9, in Los Angeles, California. Organised by the Institute of Hi-Fi Manufacturers, 28 Broad-street, New York 4.

Commercial Vehicle Exhibition, 37th International.—Thurs., Feb. 7, to Sat., Feb. 16, at Amsterdam. Offices: R.A.I. Building, Amsterdam Z.1, Holland.

Agricultural Exhibit, Fifth National.—Fri., Feb. 8, to Sun., Feb. 17, in the Show Mart, Montreal. Organised by the Salon Nationale de l'Agriculture, 152 Notre Dame East, Montreal, Canada.

National Stationery and Book Trades Fair.—Mon., Feb. 11, to Fri., Feb. 15, at the Royal Horticultural Society's Old Hall, Vincent-square, and New Hall, Greycoat-street, London, S.W.1. Organised by the National Newsagent (Exhibitions), Ltd., 149 Fleet-street, London, E.C.4. Tel. CITy 2604.

Scottish Dairy Show.—Tues., Feb. 12, to Fri., Feb. 15, at Kelvin Hall, Glasgow. Organised jointly by the Corporation of Glasgow and the Scottish Agricultural Society. Apply to Mr. Walter Barlow, Kelvin Hall, Glasgow. Tel. Kelvin 1185.

National Nylon Fair.—Mon., Feb. 18, to Fri., Feb. 22, at the Royal Albert Hall, Kensington Gore, London, S.W.7. Apply to Mr. V. G. Sherren, National Trade Press Ltd., Drury House, Russell-street, Drury-lane, London, W.C.2. Tel. TEMple Bar 3422.

Electricity and Productivity Conference and Exhibition.—Mon., Feb. 18, to Fri., Feb. 22, at the Royal Dublin Society's Show Grounds, Ballsbridge, Dublin. Organised by the Electricity Supply Board, 27 Lower Fitzwilliam-street, Dublin.

Mechanical Engineers' Contribution to Clean Air, Conference on.—Tues., Feb. 19, to Thurs., Feb. 21, in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476. See ENGINEERING, October 26, 1956, page 519.

Boat Show, International.—Fri., Feb. 22, to Wed., Feb. 27, in Miami. Offices: 615 S.W. 2nd-avenue, Miami, Florida, U.S.A.

Hardware Trades Fair, Third—Mon., Feb. 25, to Fri., Mar. 1, at the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Organised by Universal Exhibitions, Ltd. 74 Holland-park, London, W.11. Tel. PARk 7723.

Food, Cookery and Catering Trades Exhibition.—Tues., Feb. 26, to Sat., Mar. 9, at the City Hall, Deansgate, Manchester. Including food-processing machinery. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6363.

Degreasing, All-Day Discussion.—Wed., Feb. 27, at The University, Edgbaston, Birmingham. Organised by the Institute of Metals, 17 Belgrave-square, London, S.W.1. Tel. BELgravia 3291.

Motor Cycle Exhibition.—Thurs., Feb. 28, to Sun., Mar. 10, at Amsterdam. Offices: R.A.I. Building, Amsterdam Z.1, Holland.

***Leipzig International Fairs.**—*Spring Fair and Technical Fair:* Sun., Mar. 3, to Thurs., Mar. 14, at Leipzig. *Autumn Fair:* Sun., Sept. 1, to Sun., Sept. 8, at Leipzig. *Agents:* Leipzig Fair Agency in Great Britain, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

Smallwares Trade Fair.—Mon., Mar. 4, to Fri., Mar. 8, at the Metropole Hotel, Brighton. Organised by Trade and Technical Exhibitions Ltd., 1 Dorset Buildings, Salisbury-square, London, E.C.4. Tel. FLEet Street 1555.

***Agricultural Machinery Exhibition, 28th International.**—Tues., Mar. 5, to Sun., Mar. 10, at the Porte de Versailles ground, Paris. Held in conjunction with the General Agricultural Competition, at the same place. Apply to the Union des Exposants de Machines et d'Outillage Agricoles, 95 Rue Saint-Lazare, Paris 9e.

Copenhagen International Fair.—*Technical Fair:* Tues., Mar. 5, to Wed., Mar. 13. *Commercial Fair:* Sat., Mar. 23, to Sun., Mar. 31. In Copenhagen, Denmark. Organised by the International Messe, Vester Farimagsgade 6, Copenhagen V, Denmark. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

Ideal Home Exhibition.—Tues., Mar. 5, to Sat., Mar. 30, at Olympia, London, W.14. Organised by Associated Newspapers Ltd., 161-163 Queen Victoria-street, London, E.C.4. Tel. FLEet Street 6000.

Western Kenya Agricultural Show.—Fri. and Sat., Mar. 8 and 9, at Endoret, Kenya. Organised by the Royal Agricultural Society of Kenya, The Show Ground, P.O. Box No. 500, Nakura, Kenya.

***Cologne Fairs.**—*Spring Fair: Hardware and Household Goods:* Fri., Mar. 8, to Mon., Mar. 11; and *Clothing and Textiles:* Sun., Mar. 17, to Tues., Mar. 19, at Cologne. *Autumn Fair: Hardware and Household Goods:* Sat., Sept. 7, to Mon., Sept. 9; and *Clothing and Textiles:* Sun., Sept. 15, to Tues., Sept. 17, at Cologne. *Agent:* M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel.: WHItehall 8211.

***Frankfurt International Fairs.**—*Spring Fair:* Sun., Mar. 10, to Thurs., Mar. 14, at Frankfurt. *Autumn Fair:* Sun., Sept. 1, to Thurs., Sept. 5, at Frankfurt. *Agents:* Lep Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

***Vienna International Fairs.**—*Spring Fair:* Sun., Mar. 10, to Sun., Mar. 17, in Vienna. *Autumn Fair:* Sun., Sept. 8, to Sun., Sept. 15, in Vienna. *Agents:* British Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

***Junior Engineers' Meeting.**—Mon., Mar. 11, to Thurs., Mar. 14, at Chester and Manchester. Organised by the Iron and Steel Engineers Group of the Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 0061.

***Atomic Exposition and Nuclear Congress, International.**—Mon., Mar. 11, to Fri., Mar. 15, at the Convention Hall, Philadelphia. Coordinated by the Engineers' Joint Council, 29 West 39th-street, New York 16. Apply to Mr. H. F. Grebe, International Atomic Exposition, 117 South 17th-street, Philadelphia 3, Pa., U.S.A.

Motor Show, International.—Thurs., Mar. 14, to Sun., Mar. 24, in Geneva. Apply to the secrétariat général, Motor Show, 1 Place du Lac, Geneva, Switzerland.

Kansas City, International Trade Fair.—Sun., Mar. 17, to Sun., Mar. 24, at Kansas City. Apply to Mr. L. L. Bratschie, Heart of America International Trade Fair, Inc., 3230 Broadway, Kansas City 11, Missouri, U.S.A.

Photographic Exposition, International.—Fri., Mar. 22, to Sun., Mar. 31, at the National Guard Armory, Washington. Apply to Mr. R. J. Wilkinson, International Photographic Exposition, 104 East Michigan-avenue, Jackson, Michigan, U.S.A.

***Finnish Industries Spring Fair.**—Fri., Mar. 22, to Sun., Mar. 31, at Helsinki. Organised by the Finnish Fair, Mannerheimintie 17, Helsinki, Finland.

Physical Society's Exhibition of Scientific Instruments and Apparatus.—Mon., Mar. 25, to Thurs., Mar. 28, in the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Organised by the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

Western Metal Congress and Exhibition.—Mon., Mar. 25, to Fri., Mar. 29, in the Pan Pacific Auditorium, Los Angeles, California. Organised by the American Society for Metals, 7301 Euclid-avenue, Cleveland 3, Ohio, U.S.A.

Industrial Textiles Fair, Second National—Mon., April 1, to Fri., April 5, at the Royal Albert Hall, Kensington Gore, London, S.W.7. Apply to Mr. V. G. Sherren, National Trade Press Ltd., Drury House, Russell-street, Drury-lane, London, W.C.2. Tel. TEMple Bar 3422.

***Utrecht International Trade Fairs.**—*Spring Fair:* Tues., April 2, to Thurs., April 11, at the Croeselaan Site, Utrecht. *Autumn Fair:* Tues., Sept. 3, to Thurs., Sept. 12, at the Croeselaan Site, Utrecht. *Agent:* Mr. W. Friedhoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

Electrical Industries Show, Fourth National.—Mon., April 8, to Thurs., April 11, at the 71st Regiment Armory, New York. Organised by the American Electrical Industries Exposition, Inc., 19 West 44th-street, New York, 36, U.S.A.

Radio Component Show, 14th.—Tues., April 9, to Thurs., April 11, at Grosvenor House, Park-lane, London, W.1. Pre-view for overseas and special guests on Mon., April 8. Annual private exhibition organised by the Radio and Electronic Component Manufacturers' Federation, 21 Tothill-street, London, S.W.1. Tel. ABBey 4226. Applications for admission must be made in advance.

Chemical Engineering Education Symposium.—Tues, April 9, to Thurs., April 11, at The University, Birmingham. Organised by the Midlands Branch, Institution of Chemial Engineers. Apply to the secretary of the Institution, 16 Belgrave-square, London, S.W.1. Tel. BELgravia 3647.

Electrical Engineers' Exhibition, Sixth.—Tues., April 9, to Sat., April 13, at Earl's Court, London, S.W.5. Sponsored by the Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. Apply to Mr. P. A. Thorogood, Electrical Engineers (A.S.E.E.) Exhibition, Ltd., 6 Museum House, 25 Museum-street, London, W.C.1. Tel. MUSeum 3450.

British Photo Fair.—Thurs., April 11, to Wed., April 17, at Olympia, London, W.14. Apply to British Organisers Ltd., 52 Grafton-way, London, W.1. Tel. EUSton 7930.

***Milan International Samples Fair, 35th.**—Fri., April 12, to Sat., April 27, at Milan. *Agent:* Dr. V. Schiazzano, 652 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 5521.

***Saarbrucken International Samples Fair.**—Sat., April 13, to Sun., April 28, in Saarbrucken. Organised by the Saarlandischer Gestalungskreis G.m.b.H., Saarbrucken.

***Lyons International Trade Fair.**—Sat., April 27, to Mon., May 6, in Lyons. *Agents:* Robert Brandon and Partners Ltd., 47 Albemarle-street, London, W.1. Tel. HYDe Park 0901.

***Swiss Industries Fair, 41st.**—Sat., April 27, to Tues., May 7, at Basle, Switzerland. Information from the Commercial Attaché, Swiss Legation, 18 Montagu-place, Bryanston-square, London, W.1. Tel. PADdington 0701.

***Institute of Metals Spring Meeting.**—Mon., April 29, to Sat., May 4, at the Church House, Great Smith-street, London, S.W.1, except May Lecture on April 29, which will be at the Royal Institution, Albemarle-street, London, W.1. Joint meeting with the Associazione Italiana di Metallurgia, the Société Suisse des Constructeurs de Machines, and the Schweiz. Verband für die Materialprufungen der Technik. Apply to the Institute of Metals, 17 Belgrave-square, London, S.W.1. Tel. BELgravia 3291.

***Properties of Materials at High Rates of Strain, Conference on.**—Tues., April 30, to Thurs., May 2, in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1, in collaboration with the Institution's Applied Mechanics Group. Apply to the secretary of the Institution at the above address. Tel. WHItehall 7476.

***Metallurgical Aspects of the Control of Quality in Non-Ferrous Castings, All-Day Symposium.**—Wed., May 1, at Church House, Great Smith-street, London, S.W.1. Organised by the Institute of Metals, 17 Belgrave-square, London, S.W.1. (Tel. BELgravia 3291); and the Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. Tel. Blackfriars 6178.

***Lille International Fair.**—Sat., May 4, to Sun., May 19, at Lille. *Agents:* Weigel, Leygonie and Co., Ltd., 31-32 Kingstreet, London, W.C.2. Tel. TEMple Bar 4825.

British Industries Fair.—Mon., May 6, to Fri., May 17, in the B.I.F. Buildings, Castle Bromwich, Birmingham. Organised and controlled by the Birmingham Chamber of Commerce. Apply to the organisers: P.O. Box 6, 95 New-street, Birmingham 2. Tel. Midland 5021.

Spring Show and Industries Fair.—Tues., May 7, to Sat., May 11, in Dublin. Organised by the Royal Dublin Society, Ballsbridge, Dublin.

Instruments, Electronics and Automation Exhibition, First.—Tues., May 7, to Fri., May 17, at Olympia, London, W.14. Promoted by the British Electrical and Allied Manumfacturers' Association and four other trade associations. Organised by Industrial Exhibitions, Ltd., 105-106 New Bond-street, London, W.1. Tel. HYDe Park 9583.

***Scaling-up of Chemical Plant and Processes Symposium.**—Tues. and Wed., May 28 and 29, at Church House, Westminster, London, S.W.1. Organised jointly by Het Koninklijk Instituut van Ingenieurs, De Koninklijke Nederlandse Chemische Vereniging, the Society of Chemical Industry (Chemical Engineering Group), and the Institution of Chemical Engineers. Apply to the Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. Tel. BELgravia 3647.

***Institution of Engineers and Shipbuilders in Scotland: Centenary Meeting.**—Tues., June 25, to Thurs., June 27, in Glasgow. Apply to the secretary of the Institution, 39 Elmbank-crescent, Glasgow, C.2. Tel. Glasgow Central 5181.

Royal Agricultural Show.—Tues., July 2, to Fri., July 5, at Costessey, Norwich. Organised by the Royal Agricultural Society of England, 35 Belgrave-square, London, S.W.1. Tel. BELgravia 5323.

***Navigation Congress, 19th International.**—Mon., July 8, to Sat., July 20, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Sponsored by the Permanent International Association of Navigation Congresses. Apply to Mr. A. C. Morrison, secretary, British Organising Committee, at the Ministry of Transport and Civil Aviation, Berkeley Square House, London, W.1. Tel. MAYfair 9494.

Great Yorkshire Agricultural Show.—Tues., July 9, to Thurs., July 11, at Harrogate. Organised by the Yorkshire Agricultural Society, Cliftonfield, Shipton-road, York. Tel. York 3102.

British Plastics Exhibition and Convention.—Wed., July 10, to Sat., July 20, at Olympia, London, W.14. Apply to British Plastics Exhibition, Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333.

Electronics Exhibition and Convention, 12th Annual.—Thurs., July 11, to Sat., July 13, and Mon., July 15, to Wed., July 17, at the College of Science and Technology, Manchester. Organised by the Northern Division of the Institution of Electronics, 20 Buckingham-street, London, W.C.2. Apply to Mr. W. Birtwistle, 78 Shaw-road, Thornham, Rochdale, Lancs. Tel. Oldham Main 6661.

Sydney Industries Fair.—Mon., July 22, to Sat., Aug. 3, at the Sydney Showgrounds, Sydney. Apply to the Industrial Public Relations Service of Australia, R.A.S. Showground, Box 5063, G.P.O., Sydney.

Royal Welsh Show.—Wed., July 24, to Fri., July 26, at Aberystwyth. Organised by the Royal Welsh Agricultural Society, Queen's-road, Aberystwyth. Tel. Aberystwyth 7551.

***Radio Show, National.**—Wed., Aug. 28, to Sat., Sept. 7, at Earl's Court, London, S.W.5. Organised by the Radio Industry Council, 59 Russell-square, London, W.C.1. Tel. MUSeum 6901.

***Institute of Metals Autumn Meeting.**—Tues., Sept. 17, to Fri., Sept. 20, in Glasgow. Apply to the Institute of Metals, 17 Belgrave-square, London, S.W.1. Tel. BELgravia 3291.

Handicrafts, Homecrafts and Hobbies Exhibition, Fifth International.—Thurs., Sept. 19, to Sat., Sept. 28, at Earl's Court, London, S.W.5. Apply to the exhibition's organiser, 24 Store-street, London, W.C.1. Tel. MUSeum 9792.

Motor Exhibition, International.—Thurs., Sept. 19, to Sun., Sept. 29, at Frankfurt. *Agents:* L.E.P. Transport, Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

***Automatic Measurement of Quality in Process Plants.**—Mon., Sept. 23, to Thurs., Sept. 26, at University College, Swansea. Organised by the Society of Instrument Technology, 20 Queen Anne-street, London, W.1. Tel. LANgham 4251.

Fisheries Trade Fair, Second International.—Fri., Sept. 27, to Sun., Oct. 6, in the Exhibition Hall Forum, Copenhagen, Denmark. *Agents:* John E. Buck & Co., 47 Brewer-street, Piccadilly, London, W.1. Tel. GERrard 7576.

***German Brewery and International Beverage and Catering Equipment Exhibition.**—Sat., Sept. 28, to Thurs., Oct. 10, in Munich. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

***Brewers' and Allied Traders' Exhibition.**—Mon., Sept. 30, to Fri., Oct. 4, at Olympia, London, W.14. Organised by Trades, Markets and Exhibitions Ltd., 623 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 1371.

Fishing Gear, International Congress on.—In October, at Hamburg, Germany. Organised by the Food and Agriculture Organization of the United Nations, Viale delle Terme de Caracalla, Rome. See ENGINEERING, July 13, 1956, page 38.

***Book Fair, Ninth International.**—Sat., Oct. 5, to Thurs., Oct. 10, at Frankfurt. *Agents:* L.E.P. Transport, Ltd., Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

***Welding Exhibition "Lastu 57."**—Sat., Oct. 5, to Sat., Oct. 12, in the "Margriethal," Utrecht, Holland. During the exhibition a two-day symposium on **The Metallurgy of the Welding of Steel** will be held. Organised by Nederlandse Vereniging voor Lastechniek, 62, Zeestraat, The Hague, Holland.

***Electronics Conference Exhibit, National.**—Mon., Oct. 7, to Wed., Oct. 9, in the Hotel Sherman, Chicago. Organised by the National Electronics Conference, Inc., 84 East Randolph-street, Chicago 1.

***Engineering Industries Association; 10th London Regional Display.**—Wed., Oct. 9, to Fri., Oct. 11, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Apply to the secretary of the Society, 9 Seymour-street, London, W.1. Tel. WELbeck 2241.

***World Metallurgical Congress, Second; and 39th National Metal Congress and Exposition.**—Sat., Nov. 2, to Fri., Nov. 8, in Chicago. Organised by the American Society for Metals, 7301 Euclid-avenue, Cleveland 3, Ohio, U.S.A.

***"macroPlastic" International Plastics Fair.**—Wed., Nov. 13, to Wed., Nov. 20, in the RAI Buildings, Amsterdam, Holland. Organised under the auspices of the Dutch Government's Industrial Board and the Plastics Research Station of the Technical University. Further information obtainable from N.V. 't Raedthuys, Tesselschadestraat 5, Amsterdam, Holland.

Building Exhibition, 27th.—Wed., Nov. 13, to Wed., Nov. 27, at Olympia, London, W.14. Organised by the Building Trades Exhibition, Ltd., 32 Millbank, London, S.W.1. Tel. TATe Gallery 8134.

***Chemical Industries Exposition, 26th.**—Mon., Dec. 2, to Fri., Dec. 6, at the New Coliseum, New York. Organised by the International Exposition Co., 480 Lexington-avenue, New York 17, U.S.A.

Fig. 1 To save time in conveying staff from the drillings in Lake Maracaibo, three 50 passenger high-speed launches are to be used. Driven by two nine-cylinder Deltic engines, the launches will have a speed of about 30 knots.

HIGH-SPEED WATER-BUS

COMMERCIAL USE OF THE NAPIER DELTIC ENGINE

Three high-speed passenger launches are being built by John I. Thornycroft and Company, Limited, Woolston Works, Southampton, for the Cia Shell de Venezuela. Each will be driven by two nine-cylinder Deltic Diesel engines. It is stated that this is the first commercial marine application for this type of engine.

The launches, the first of which was recently demonstrated, are for use on Lake Maracaibo, in Venezuela, for conveying the staff to and from the drillings which are situated in the middle of the lake itself. The lake measures approximately 100 by 70 miles, and some of the drilling sites are 40 miles from the base. Consequently, time spent in taking the staff to and for represents a considerable proportion of the day and it was for this reason that high-speed launches were required. Strength was also necessary as the lake has much floating debris in it, including tree trunks and timber baulks from the drilling stations.

The launches measure 68 ft. 3 in. in length, 17 ft. 5 in. in breadth and have a moulded depth of 9 ft. 4 in.; the draft is approximately 5 ft. 6 in. They are steel hulled to withstand the shocks of service, but the greater part of the superstructure is of light alloy. The displacement is of the order of 48 tons.

The two nine-cylinder Napier Deltic engines are to be mounted aft, as is shown in Fig. 2, each driving an outboard-turning screw (ahead running). Both are fitted with ahead and astern reduction gearboxes. The rating of the engines has been reduced from 865 s.h.p. to 810 s.h.p. to allow for the climatic conditions in the area. A speed of 31 knots can be obtained with the two engines, and the launches have seating capacity for 46 in the cabin and four in the wheelhouse, as well as for the helmsman and two lookouts. The passenger cabin has seats arranged in three groups, with two gangways running the length. 'Bus type seats of steel and alloy tubing with cushions and backs of rubberised hair or foam rubber, are used both here and in the wheelhouse. As may be seen from Fig. 1, the lookouts and helmsmen are placed rather high above the water-line so that floating debris will be detected at some distance. Each of the windows in front of the pilot and the lookouts is fitted with a Kent Clear View screen which is necessary in view of the considerable spray that is produced when the launch is travelling. An unobstructed view astern is also possible from the wheelhouse.

The engines are independently controlled by means of Teleflex gear, and an indicator panel by the helmsman repeats the readings of the panels in the engine room. In order to keep the beam dimensions down, the engines have been slightly staggered fore and aft, which also permits access between them for inspection. Starting, making use of Teddington equipment, is automatic once the button is pressed by the helmsman. Each engine is fitted with a combustion-type starter in which a cartridge is fired into a cylinder containing a piston mounted on a helically splined shaft carrying a Bendix type claw coupling. The starter is mounted on the phasing gear casing, its claw engaging with a similar one on a gear meshing directly with one of the upper crankshafts. Five cartridges are contained in a rotary breech which is indexed and electrically fired from the engine control compartment. The starting switch operates, in turn, priming of the engine lubricating oil and fuel oil systems before firing the cartridge. A time switch automatically indexes the breech for the next start.

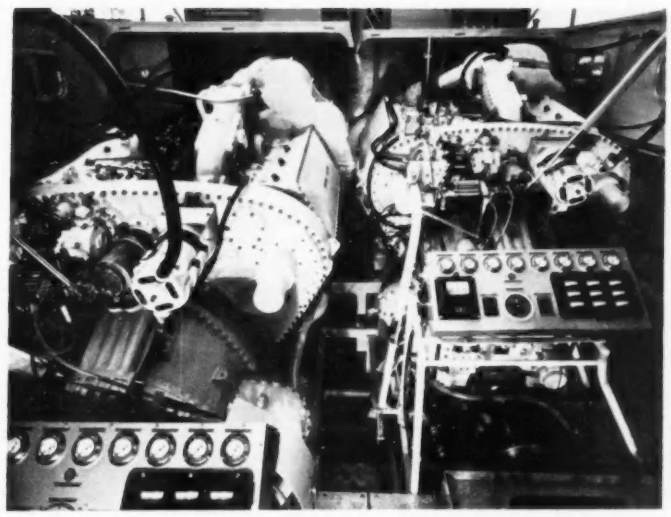


Fig. 2 The two engines are staggered fore and aft to enable the beam to be kept to a minimum. In the illustration the hatch covers have been removed, showing the space available for maintenance.

Because of the conditions under which the launches will operate the maximum ventilation is necessary and the two forward hatches are fitted with quandrants which will allow them to be partly open for this purpose or fully open for use as escape hatches. There are two entrances to the cabin, one on each side of the vessel, and a central entrance to the engine room at the stern.

The hull is divided by means of three watertight bulkheads into four compartments—fore peak, passenger cabin, machinery space and steering compartment. The deck has been stiffened to carry deck cargo aft. Fuel tanks mounted aft of the engine room hold approximately 350 gallons of Diesel oil and are constructed of 8 gauge aluminium alloy. A freshwater tank of 25 gallons capacity, also of aluminium alloy, is included. Two balanced spade-type rudders with steel blades welded to steel stocks are fitted and Mathway steering gear controlled from a 21 in. diameter wheel at the centre line of the launch is used.

* * *

THIN CONYEYOR BELTS

Efficient and Economic

A recent test programme carried out by E. I. du Pont de Nemours and Company, Wilmington 98, Delaware, U.S.A., in conjunction with the Link-Belt Company, comparing a light thin four-ply belt reinforced with Cordura rayon yarn with a conventional five-ply cotton belt of the same strength, has shown that the thin rayon stands up as well in service as the thicker cotton belt and is slightly more economical in power requirements. The belts were compared on the same conveying system under wide variations in load and speed, for about 1,000 hours. Observations were made on general performance, power requirements, and on the belt contours between carrier idlers.

Quoting from the conclusions drawn by the Materials Handling Laboratory of the Link Belt Company, " It has been claimed that cotton belts having less than recommended minimum plies are too 'flimsy,' which leads to excessive sagging between carriers, particularly toward the edges, causing spillage and load disturbances with higher horse-power requirements. Also that the belt can be forced into the gap between the idler rolls and pinched. The lighter weight rayon belt did not indicate any of these troubles during this test, but in comparison was found to be equivalent in performance to the heavier cotton belt." The report postulated that " flimsiness " in belts would result from lack of adequate tension capacity to resist sag rather than from the thinness of the belt itself.

" Within the range of conditions covered in these tests, we found no significant difference in the practical operating characteristics of the rayon and cotton belts, which were of equal strength. Since the conditions were deliberately chosen to exaggerate any harmful effects of flexibility, it seems reasonable that the same characteristics might apply to all weights and lengths of belts operating at tensions determined by conventional design methods and carrying materials of relatively small lump size. Also, under practical operating conditions, the contour of any belt is largely determined by the applied tension and the shape and spacing of the carrier idlers. Greater flexibility of the rayon belt seems to have no bad operating effects. The greater flexing endurance reported by laboratory tests suggests that the rayon fabric belt could flex around smaller drive pulleys with resulting higher drive shaft speeds permitting small gear reduction components having lesser cost and greater overall efficiencies. The lower elastic stretch of the rayon belt should result in reduced take-up requirements."

Since this test was completed, Du Pont have introduced Type 272 Super Cordura high-tenacity rayon yarn, stronger and tougher than any previous rayon used for belting. The company claim that the new yarn can be expected to have even better performance than the test yarn in the reported field tests.

THE HUMAN ELEMENT

Women's ability as advisers—When does free comment become interference?—The ambitious workman must not be forgotten—Americans turn to security—Bold experiment in social welfare—Unhappy prologue to expected wage claim.

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Women Engineers

For the first time a woman, Miss Mary Isolen Fergusson, of Edinburgh, has become a full member of the Institution of Civil Engineers. There are at present 4 other women on the roll. There are 5 women on the roll of the Institution of Mechanical Engineers, of whom one is a full member, and there are 28 on that of the Institution of Electrical Engineers, not one of whom is a full member. Miss Fergusson's transfer breaks new ground. Not only is she the first female full member but she has achieved full status in a profession which has so far been considered a particularly male preserve since the professional working conditions are considered more suitable for men than for women.

The end of a prejudice is always to be welcomed. In this case it is particularly so for her election will stand as a sign that more and more women will be admitted, even welcomed, into the engineering profession. This must be so. In the modern world countries with much larger reserves of manpower than here (especially Russia) are training women to the engineering profession. Where Russia has gone, at least in this respect, others may well follow.

It is arguable that highly trained women are more suitable for a career in one of the professions than they are in high executive positions. The essence of professional work is the personal relationship between adviser and client, with great emphasis on the technical expertise of the adviser. Attributes of this sort are in many cases happily developed in a woman; a position of wide authority in a big organisation involving power and control of men in large numbers is a difficult combination for a woman to handle if she feels under any obligation to prove her ability to do a man's job.

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"Interference" in Union Elections

Last week the Amalgamated Union of Foundry Workers annulled the election of a national organiser on the grounds that there had been interference by an outside organisation in giving favourable mention to one of the candidates—the one who was elected. The appeal of the unsuccessful candidate was heard by an independent court made up from members of other unions. There will, in consequence, be another election.

Union rules to prevent what is considered to be outside pressure of this sort are of long standing. They were originally drafted in the craft unions to prevent a candidate with sufficient resources disseminating literature to support his candidature. Such precautions were necessary in an age when electioneering in all walks of life was robust rather than scrupulous. To-day a rule of this kind is an anachronism, and can be a disservice to a union if it is given too wide an interpretation. In this case, favourable allusions were made to the successful candidate by an anti-Communist publication and marked copies were circulated among union members. The court, presumably, classes this sort of activity with the clandestine use of the printing press by an interested party—a decision which to many will appear wrong, and possibly dangerous. The decision appears to be more a warning to the publication not to interest itself too much in the internal affairs of individual unions than an upholding of a union rule.

In matters of this kind it is the thought of where decisions may lead that should give pause. There have been cases in the past where outside comment, in newspapers for instance, has been cited as an infringement of union rules, thus hampering a candidate of whom there has been favourable mention. Communist groups have used it to defend the chances of unlikely candidates. The issue needs re-thinking and the rules amending.

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Respectable Mediocrity

In the second edition of *The Nature of Management* by Mr. H. R. Light, published this month, the last chapter deals with "Some Modern Tendencies." Two tendencies stand out, namely, the trend towards automation and the popularity of the group idea in current industrial social thinking. Since this is a book for the student of management the last of these in particular is worthy of special comment.

Ideas about the significance of the group vary, but they all accept the concept that man is a gregarious animal who wishes to come to terms with his social environment and find security within it. Since a man spends a very large part of his time at work it follows that he should find social satisfaction in his working group. This idea has many attractions and helps to explain a number of things in the average factory worker's attitude on the shop floor which cannot be related directly to the wage packet. Recent social surveys have shown the importance which men attach to working conditions—by which they usually mean their social, rather than their physical, environment.

As these ideas percolate into the text-books it is as well to emphasise that they refer to the average, the typical worker. They explain little about the ambitious type, the one troubled with some divine discontent. It is imperative to use such concepts as "the group" as tools only, not as desirable criteria in all circumstances. If that is done, mediocrity will have been given the respectibility of a social theory and perhaps be accepted as a desirable end.

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Attachment to the Job

The growing importance that workers attach to security in American industry is evident from statistics quoted by the Commissioner of the U.S. Bureau of Labor Statistics. In his view the decreasing mobility of workers may threaten the dynamism of the manufacturing industry. Fewer and fewer are leaving their jobs voluntarily: "quit rates" were down to 17 per 1,000 in October and fell further to 13 per 1,000 in November. The possibility that this may mean a falling confidence in finding another better job is mentioned; workers tend to stay where they are if they fear employment opportunities are declining. But American industry is booming, and there are other, more likely explanations.

Since the war there has been a strong movement towards security throughout U.S. industry. The growth in union strength and influence has produced a spate of agreements formalising or introducing guarantees of security, such as the guaranteed annual wage, safeguards and compensation for redundancy, elaborate seniority rules and other clauses which tend to increase the attraction of staying put. On their own initiative managements have introduced company welfare on an unprecedented scale, and there has been a considerable and rapid growth in profit-sharing schemes. The fear of redundancy—associated in most cases with automation—and the desire to reduce labour turnover have combined to produce a set of conditions in which most workers find it to their advantage to stay put.

The United States, like the more highly industrialised and wealthy nations in the Western Hemisphere, is sliding fast into the habit of safety first. Perhaps also a new set of values is being superimposed on the old: leisure and ways of using it increasingly command a premium over money and ways of making more.

German Pension Experiment

One of the most ambitious and controversial national pension schemes ever given official approval is likely to go on the statute book in Western Germany very shortly. The scheme, briefly, covers all workers earning up to £1,250 a year. Pensions will be paid on average earnings over a man's working life at the rate of 1·5 per cent. of each year's wages, and will be adjusted for changes in the purchasing power of money.

At present, pensions contributions account for 11 per cent. of wages, and it has been calculated that this will increase to 16·75 per cent. by 1980 under the new arrangement. This is a heavy burden but Dr. Adenauer, who is putting the scheme through against a good deal of expert opposition, thinks it not too high in order to remove fear of old age. His attitude is understandable on two grounds. He is elderly himself and can understand the positions of others of his age. He has lived, too, in an age of heavy unemployment between the wars and he has seen a generation of the German middle class wiped out financially by the great inflation of the 1920's. His critics fear the burden of the scheme on the national income when the average age of the population is rising, and its effect on the incentive to save.

One safeguard of a sort has been put into the bill which will give the Government an annual review of the scheme and enable it to suspend pensions increases. It nevertheless represents a heavy and bold overhead expense on the future earning power of the German economy, and it could still stimulate the conditions it has been designed to counteract, namely, popular indifference as to the purchasing power of money. Other industrial communites will follow the experiment with interest.

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Tilbury's Tally Clerks

The unofficial strike started last week by the tally clerks of Tilbury shows how sensitive dock workers remain to any threat, however slight, to established privilege. Tally clerks, known in the docks as O.S.T.'s, carry out the checking of cargo on ship, quay or warehouse. They constitute a small proportion of the dock labour force—about 1,700 in London compared with 31,000 dockers—but have a long history of union organisation which dates back to the 1880's. They are conscious of their strongly traditional status and jealous of their organisation. Although they are "out-workers" and have no right to cargo documentation work in shippers' offices there has been a tendency since the war to employ them to supplement office staff, particularly in Tilbury. This tends to give them a permanency greater than they had formerly and has become a valued "perquisite."

The trouble started when a new company, West African Terminals, was formed to handle stevedoring for three West African shipping lines who had previously used the services of existing stevedoring companies in the Royal group of docks. The company moved to Tilbury and wanted to transfer some of the permanent office staff who had been doing the work of the three shipping lines concerned. The Tilbury O.S.T.'s saw a threat to their positions in offices, and 170 of them withdrew their labour, followed by some of the tally clerks in the West India and Millwall docks. By the week-end, 259 men were on strike and over 3,000 dockers were unable to work in consequence. A meeting of all London's tally clerks except the strikers, called by the T. & G.W.U., passed a resolution that the strike should end immediately "in order that negotiations with the employers can proceed forthwith" by a majority of 81 votes. The strikers rejected this, claiming they had not been properly notified about the meeting.

This is an unfortunate curtain raiser to the new wage claim expected soon on behalf of the 100,000 dock workers in Britain. Much remains to be done to bring industrial peace to this troubled industry.